SIEMENS June, 2005

Technical Journal

'Out of the Box' Ground Fault Protection

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There is no question that the Ground Fault (GF) trip function can be a useful tool in the circuit protection arsenal. However, its use requires careful consideration of the part of the distribution system designer. According to the National Electrical Code (NEC) Article 230-95, ground fault protection is optional on all low voltage systems (600V and less) with service disconnects below 1000A. It is also optional on solidly grounded systems with less than 150Vac to ground, such as 208Y/120V. This article does require GF protection for 1000A and greater service disconnects on common systems like 480Y/277V. It further requires a maximum pickup setting of 1200A and a maximum time delay of 1 second. However, the NEC also recognizes a balance of this protective function with the need for selective trip coordination. Exception No. 1 waives the GF requirement "for a continuous industrial process where a nonorderly shutdown will introduce additional or increased hazards."

Selective trip coordination and system protection are two necessary but mutually contradictory goals and the achievement of one is usually at expense of the other. ANSI/IEEE Standard 242 (Buff Book) puts it this way:
"1.1.2 Equipment Damage Versus Service Continuity. Whether minimizing the risk of equipment damage or preserving service continuity is the more important objective depends on the operating philosophy of the particular plant or business."

The decision to employ GF tripping should be based on NEC requirements and system design considerations. After that determination is made, the GF trip settings must be carefully evaluated. The NEC 1200A maximum setting may seem ample. However, calculations and tests have shown that a typical single phase arcing ground fault is in the range of 19-40% of the bolted fault level[1]. To choose a conservative example, for a 480V system 22,000A would be a fairly low bolted fault level. Using 19% as the conservative value, the ground fault current for this system would be approximately 4180A. This is more than 3 times the 1200A max setting available at the main. Even given some fault limitation by other system impedance factors, chances are the ground fault current will approach 1200A. How can GF trip coordination be achieved with multiple levels when the system main is limited to 1200A?

Given the relatively low 1200A limit at the main, the principle tool for trip coordination is the GF time delay function. Again referring to the IEEE Buff Book, 7.3.4 "Selection of Low-Voltage Protective Device Settings" offers this:
"Maximum protection against ground faults can be obtained by applying ground fault protection on every feeder circuit from source to load. The minimum operating current for all series devices may be ***set at about the same pickup setting***, but the ***time curves are selected so that each circuit protective device is opened progressively faster***, moving from the source to the load."

Italics were added to emphasize the key phrases. Coordination can be achieved through time delay selection even given the same pickup setting at different levels of the system. Of course the variation in pickup current should be considered, but plays a relatively minor role given the typical magnitude of a ground fault and the ability to coordinate with time delays.

How much does the GF time delay affect system protection? Even with typical time delays, the protective benefit of GF tripping is still achieved through its capability of clearing a GF within a few hundred milliseconds rather than tens of seconds or minutes that other functions such as Long Time tripping would require.

Another important issue, given the necessary GF sensitivity, is nuisance tripping. All AC distributions systems have some GF leakage current and GF pickup settings must be set high enough to allow for these. In addition, harmonic levels are ever increasing in distribution systems today. Harmonic currents, especially higher orders, can cause false GF tripping when the GF pickup settings are low - in the 20-30% range. Several instances of this have been seen in different types of installations.

A well designed distribution system will balance all of these considerations. As an aide to the system designer, Siemens offers a range of trip unit functions.

[1] From "A Practical Guide to Ground Fault Protection" 1995 published by the Intertec Electrical Group

The latest innovation is the VL line of MCCBs which offer GF protection at levels better than required by Code and yet achieve "Out of the Box" automatic GF trip coordination. Figure 1 shows the time current curves for the 545 Model electronic trip units and clearly shows the trip coordination. Note that the pickup and time delay are fixed for each frame and are listed in the table. These settings are a careful balance of protection and coordination following the principles discussed above and other industry sources for the latest design criteria.

Should the system designer require more flexibility for more complex circuit protection needs, the 576 Model offers a full range of settings. The GF pickup settings vary from 40-100%. The lowest setting was chosen to reduce the possibility of nuisance tripping in modern distribution systems while the highest setting is always equal to or less than the maximum allowed by the NEC. Time delay settings range from 100 to 500 milliseconds. These settings were also chosen to achieve the desired GF protection with the ability to allow needed time delays for selective trip coordination.

The Siemens VL family of circuit breakers gives a system designer the choice of using 'out of the box' GF coordination with the fixed Model 545 trip units or the ability to program a custom scheme with the adjustability available on the Model 576.

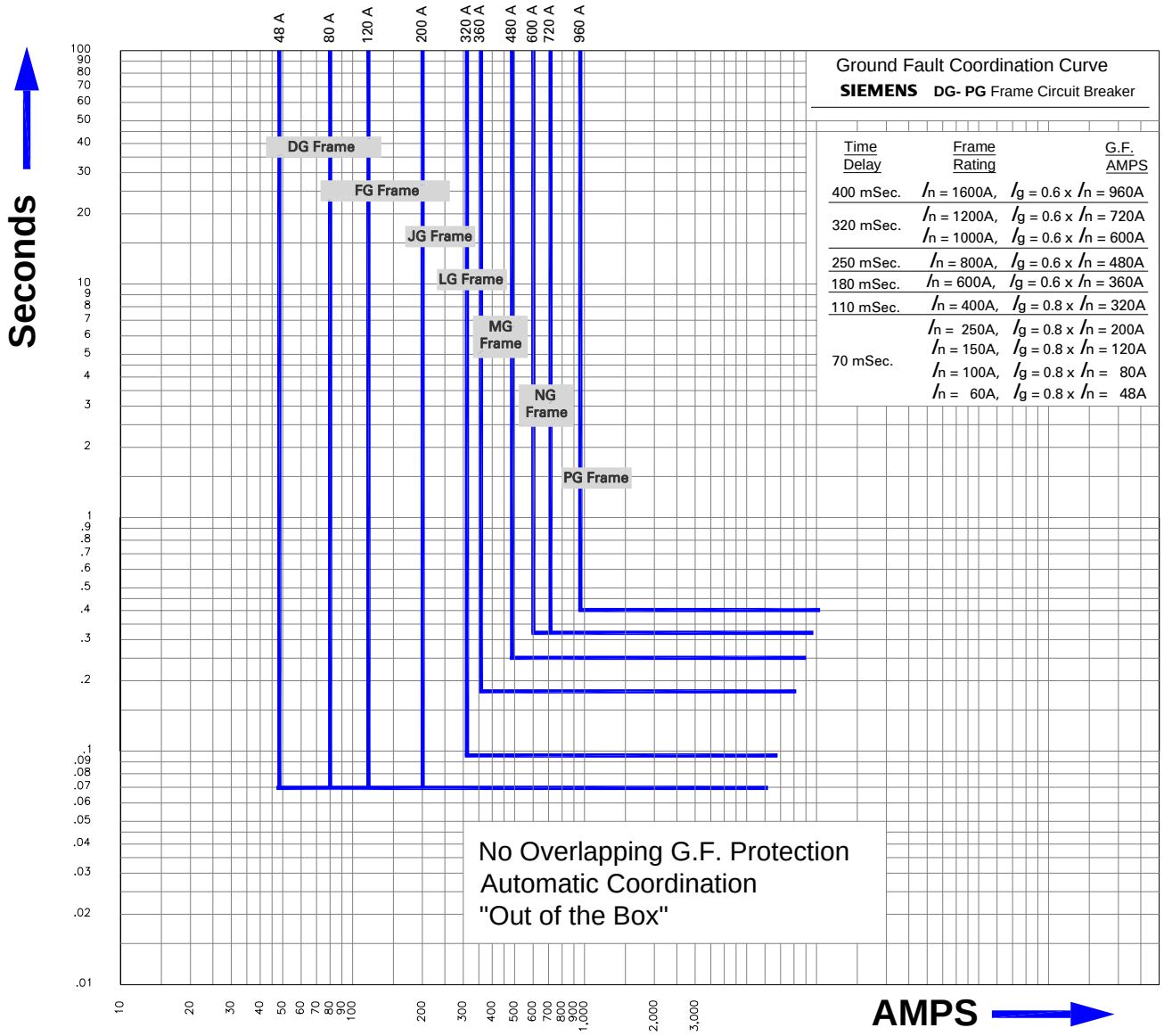

Figure 1