by Iony Patriota de Siqueira

Brazilian Transmission Line Protection

Issues & their Solutions

The main issue related to transmission line protection seems to be the large number of specific cases.

The Brazilian electric system is singular due to its large geographical area, supplied mainly by hydro power plants located on rivers far from the load centers. The main generation source is Itaipu, a binational (Brazil & Paraguay) power plant with an installed capacity of 12,600 MW. Large portions of the Brazilian territory, mainly on the Amazon region, remain attended by isolated thermal systems, with scarce transmission resources. At the other extreme, highly dense load centers are located on main industrial and metropolitan areas on the Atlantic coast. The following picture shows the main transmission corridors and international connections of this system, covering an area superior to that of the whole Western Europe

To cover such a large area, Brazilian electric system has more than 1150 transmission lines (greater than 69kV) at 138, 230, 345, 440, 500 and 750kV, linking over 600 substations, most considered long transmission lines (> 30km). The highest voltage in use links Itaipu power plant to the Sao Paulo area by two 565 mile (910 km), 750-kV AC lines and two 600 mile (980 km), 600-kV DC lines. The 500-kV technology is mostly based on compact transmission lines with self-supporting steel towers that have been successfully used on the Brazilian system for more than 10 years. Load concentration has also determined the need for short transmission lines (< 30km) connecting mainly urban stations.

Many special issues need to be dealt in the protection of a system this large, from zone reach settings and selectivity of short lines to high line charging with low short circuit current in 500kV long lines. On series compensated lines, several special measures are taken: zone 1 setting is disabled when capacitor is located at the remote end and the line is 70% compensated (overreaching of 2nd/3rd zones may occur, especially when there are capacitors at the remote end or at the beginning of the next line).

Voltage inversion is dealt using positive sequence voltage memory polarized relays, while overreaching due to sub-synchronous resonance between line and capacitor is compensated for Zone 1 (when enabled) by means of a security factor. Fault location errors occur for specific cases. Current inversions are not common, but have been recently detected during a protection type test using RTDS for some lines in the Southwest 230 kV system.

In mutually coupled lines, overreaching of ground Zone1 due to zero sequence current reversals dictates the use of mutual compensation. In lines with tapped loads, Zone1 settings are compensated for under-reaching due to in-feed effects.

The following protection philosophies are used: two identical distance or differential plus distance protection (Main 1 and Main 2) for all 500kV and new 230kV lines (after Grid procedures took place), with redundant batteries and trip coils. Primary and backup distance plus ground overcurrent protection continues to be used in old 230kV lines, with single battery and trip coil. Single pole trip and reclosing is used on selected 500kV lines for SLG faults. Communications are used for some line differential protection and teleprotection (all 230kV and above) in several schemes: Permissive Overreaching Transfer Trip (POTT), Permissive Underreaching Transfer Trip (DUTT), and Direct Transfer Trip (DTT). Blocking is used for power swings, with tripping when separation of interconnected systems is required. Load encroachment has not been necessary but is available on the relays.

Adaptable multifunctional digital relays, supporting interoperability with other schemes looks like the right direction to their solution. ■

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