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Analysis of overload conditions in distance relay under severe system contingencies

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ABSTRACT

Distance relay protection is widely used worldwide for protection scheme on high voltage transmission lines. This protection tends to be prone to load encroachment condition causing possible undesired tripping condition. Investigations of two system disturbances that occurred in TNB's (Tenaga Nasional Berhad) Grid in the year 2003 and 2005 have clearly revealed the occurrence of load encroachment condition following line overloads after large number of line tripping. Examination of the impedance locus trajectory during the overload events have enabled a distinction be made between power swing and load encroachment phenomena. This paper presents the analysis and findings of the investigation of the load encroachment phenomena of the two events, including other related transmission line contingencies.

1. Introduction

Power transmission lines are commonly utilised for bulk power transfer in a modern electrical power network. Since the transmission lines are exposed to outdoor environment, they are susceptible to risk of outages due to faults, lightning strikes etc. Power transmission lines failure rate is typically much higher than other facilities and consequently their protection performance needs to ascertain high degree of dependability and reliability.

Distance or impedance protection is extensively used for protecting high voltage transmissions in electrical power networks [1], particularly because it is capable of detecting various types of line faults and provides time-delayed backup protection function for adjacent line and busbar faults. Furthermore distance relays are sensitive to detect power swing and load encroachment conditions that could occur during power system disturbances, particularly involving cascaded line trippings and subsequent line overloads [2].

The phenomenon of load encroachment has contributed to two previous system incidences in TNB system, i.e. in September 2003 and January 2005. In both incidents the undesired tripping operations of distance relays were attributed to load encroachment condition. Therefore, load encroachment phenomenon needs to be better understood in order to prevent future mal-tripping involving distance protection in TNB [3] power system.

2. Power swing and load encroachment phenomena

2.1. Power swing

Power swing is a phenomenon that occurs after a short circuit or fault has been removed from the system, or when switching operation is carried out causing oscillation in both current and voltage vectors. During power swing condition the load impedance locus oscillate between its initial position and distance relay tripping zones at a speed that depends on the frequency of power oscillation. Power swings are typically phase symmetrical events with fairly long cycle times [4].

2.2. Load encroachment

Load encroachment is associated with a sudden increase in loading of a very long line which results in load impedance as seen by a distance relay to be of similar order in magnitude as short circuit or fault impedance. For a double-circuit line, this could occur following a loss of one circuit. During load encroachment, several oscillations of current and voltage vectors are also present, similar to power swing impedance trajectory. The impedance locus as seen by distance protection oscillate between its initial position and distance relay tripping zones before it remains in one of the tripping zones as overload reaches steady-state [5]. If impedance locus remains in the tripping zone beyond the zone time delay setting then tripping operation is imminent even though no actual fault is present in the system.

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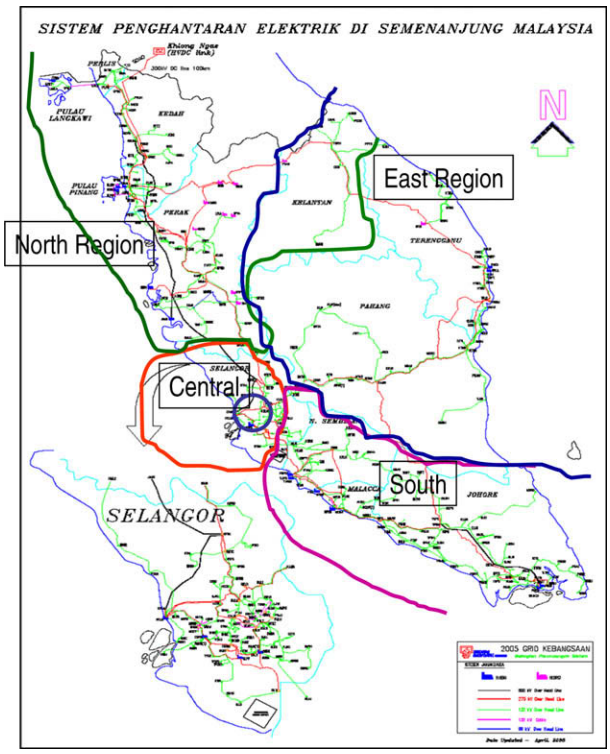

Fig. 1. Peninsular of Malaysia power grid (2005).

3. Load encroachment incidents

Two recent power blackout incidents experienced by Peninsular of Malaysia are discussed in this paragraph:

- Northern and Eastern Region of Peninsular Malaysia Partial System Blackout on the 1st September 2003.
- Southern and Central Region of Peninsular Malaysia Partial System Blackout on the 13th January 2005.
- The regions affected can be seen from the Grid Network shown in Fig. 1 below.

3.1. Northern and Eastern Region of Peninsular Malaysia partial system blackout on the 1st September 2003

Monday September 1st, 2003 was a public holiday for Malaysia except for the four Northern Peninsular states of Perlis, Kedah, Kelantan and Terengganu. Taking the opportunity of the public holiday, TNB scheduled 14 transmission line outages in the morning for maintenance and other purposes, two of which were on the 275 kV network. Several power plants were also not available following maintenance outages over the long weekend. The planned generation scheduled for the Northern region was a typical because the area was net importer of power. Prior to the incident at 09:58 h the Northern region was importing from Central and Eastern regions amounting to approximately 966 MW to cater for a total load of 1922 MW. The total power imported from the Central region was 600 MW where 487 MW was through 275 kV lines between Bukit Beruntung and Batu Gajah whilst the remaining

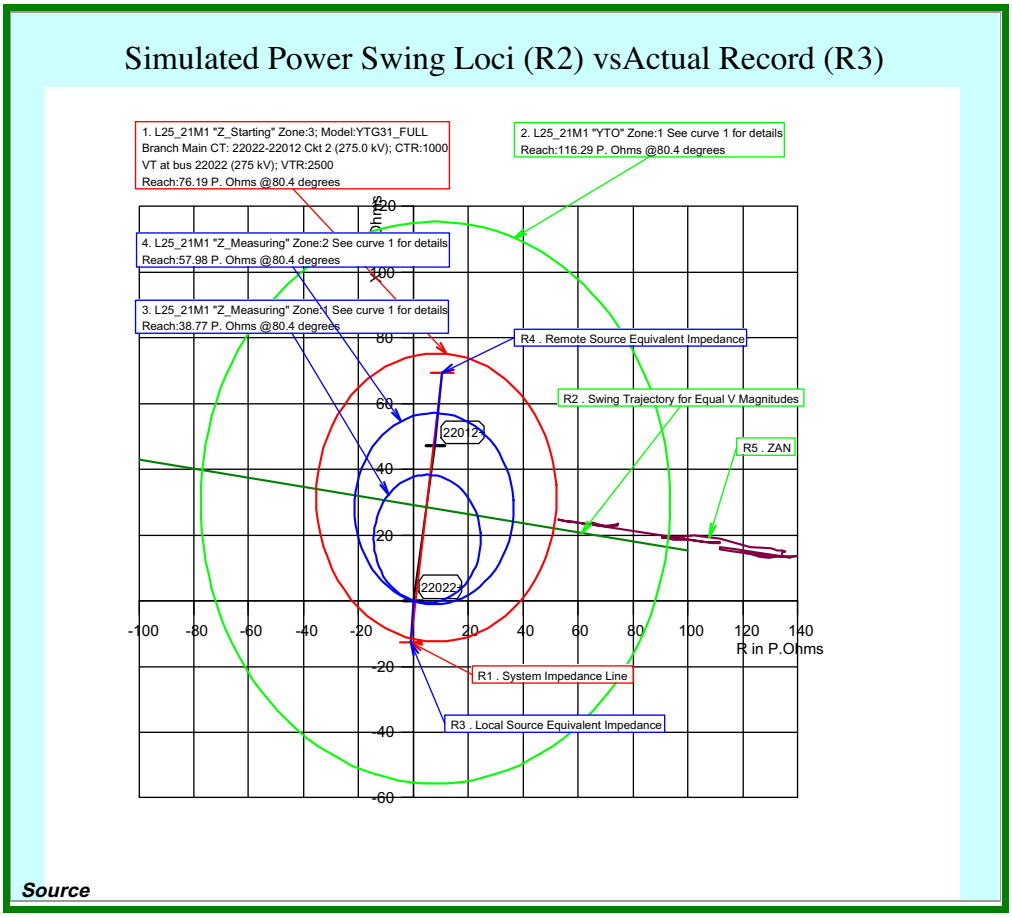

Fig. 2. Impedance locus of 1st September 2003 event.