Investigation on Transient Stability of an Industrial Network and Relevant Impact on Over-current Protection Performance

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Abstract— **System protection performance and transient stability of the electrical network are significantly affected by each other. The larger the time delay in which protection detects and clears the fault, the more likely loss of synchronism will be, especially in the networks with internal generation. Over current protection schemes inherently operates with considerable delay. Moreover, system dynamic oscillations discernibly aggravate their performance. Therefore utilizing them as main protection is controversial and even abortive in order to maintain system stability. In this paper, transient stability of a real industrial network is studied. The study is investigated using critical clearing time (CCT) criterion for different network configuration. Equipments such as generators and motors are modeled and simulated by DIgSILENT software. In addition, the operation of over current relays adjusted by conventional methods is investigated dynamically and its performance is examined under different network configurations.**

Keywords—**transient stabilty, over current protection,dynamic simulaiton, critical clearing time (CCT)**

I. Introduction

Transient stability is one of the most important criteria in reliability evaluation of industrial networks [1, 2]. Power system protection performance in conjunction with transient stability of power system has been studied for years [3]. In the case of losing stability, a considerable amount of electrical load will usually be shed due to operation of protection system, mostly under-frequency and under-voltage protections potentially leading to sporadic disconnection of sensitive loads [4]. This blind shedding may end up to a process interruption and also corruption of electrical equipments [5, 6]. Therefore, investigating transient stability together with scrutinizing operation of system protection will certainly reveal probable imperative deficiencies.

As soon as a large disturbance occurs in the network, synchronous generators will be affected due to sudden decrement or increment in output electrical power and begin to swing [1]. In contrast to electrical power, during disturbance period, mechanical power is approximately constant due to very slow response of governor-turbine set. Difference between these two powers is called accelerated power is crucial parameter in transient stability studies. Some generators may experience out-of-step condition, depending on this quantity which implicates the severity of the disturbance.

When a generator loses synchronism, its rotor speed will be higher or lower than necessary speed for generation of power frequency voltage. In this case, the angle between rotor field and armature field severely oscillates. These two fields slip through each other alternatively leading to consecutive absorption and injection of active power. This successive exchange of active power in conjunction with high current magnitudes causes dangerous torque and is able to twist the turbine-generator shaft detrimentally [7]. In addition, transient stability of the power system will severely be deteriorated if no immediate disconnection of the instable generator is devised.

Some weak points in the network will be revealed through transient stability investigation which can be resolved or at least effectively mitigated with special measures like protection operation enhancement, appropriate adjustment of generator fast-response controllers and interconnecting the network much more like closing some coupler breakers [8].

Generally, the goal of transient stability study is to investigate non-linear dynamic response of the equipments to the disturbances [9]. However, accuracy in equipments modeling is largely affected by investigation purpose. For instance if the purpose is confined to study first rotor angle oscillation indicating capability of maintaining synchronism, accurate modeling of excitation system can be ignored and a simple model can be used instead. However, if the purpose is adjustment of load shedding relays, excitation system and even turbine-governor set must be modeled with special attention.

In this paper transient stability has been studied in an industrial network. The power system under study is introduced in section II. In section III, suitable modeling for present research is briefly reviewed. In the following, section IV, transient stability study is performed using critical clearing time (CCT) criterion. Finally, over current protection as main protection in this MV network is dynamically analyzed in section V and it's highlighted that over current protection traditionally coordinated is likely to operate inappropriately during the severe faults.

II. System Under Study

This research has been carried out on a real industrial network supplying process unit loads and MV motors in voltage level of 6 kV. It consists of two sub-networks named Northern and Southern sub-networks. They independently