

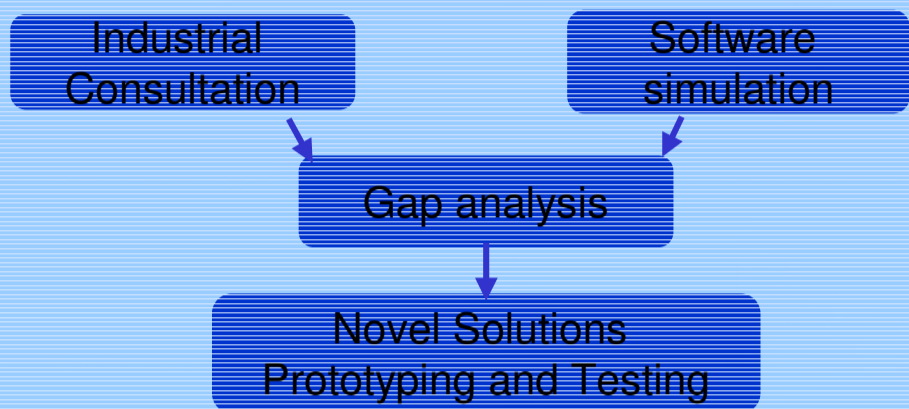
Novel Protection Methods for Active Distribution Networks with High Levels of Distributed Generation

Introduction

With growing penetration levels of small scale generation connected at the distribution levels, it is anticipated that existing practices in power system protection may not be sufficient to accommodate planned penetration levels of DG in the future. It is therefore imperative to identify and systematically address protection system gaps which could pose a barrier to further DG integration.

Methodology

The adopted methodology for supporting industry in protection related issues was based on the combination of the direct industrial consultation and software simulation studies followed by software and hardware prototyping and testing.



Main Identified Issues and Suggested Solutions

1. Loss-of-mains

It has been recorded that loss-of-mains protection does not operate properly on many occasions. This incorrect operation is normally in the form of nuisance trips, which consequently results in loss of local generation.

Possible Solutions: Improved frequency estimation algorithms, communication based protection.

2. Islanding

According to prevailing legislation, islanded operation is not yet viewed as a viable mode of operation in the UK. This situation, however, is likely to change in the future and protection systems are required that can adequately perform under both islanded and interconnected system conditions.

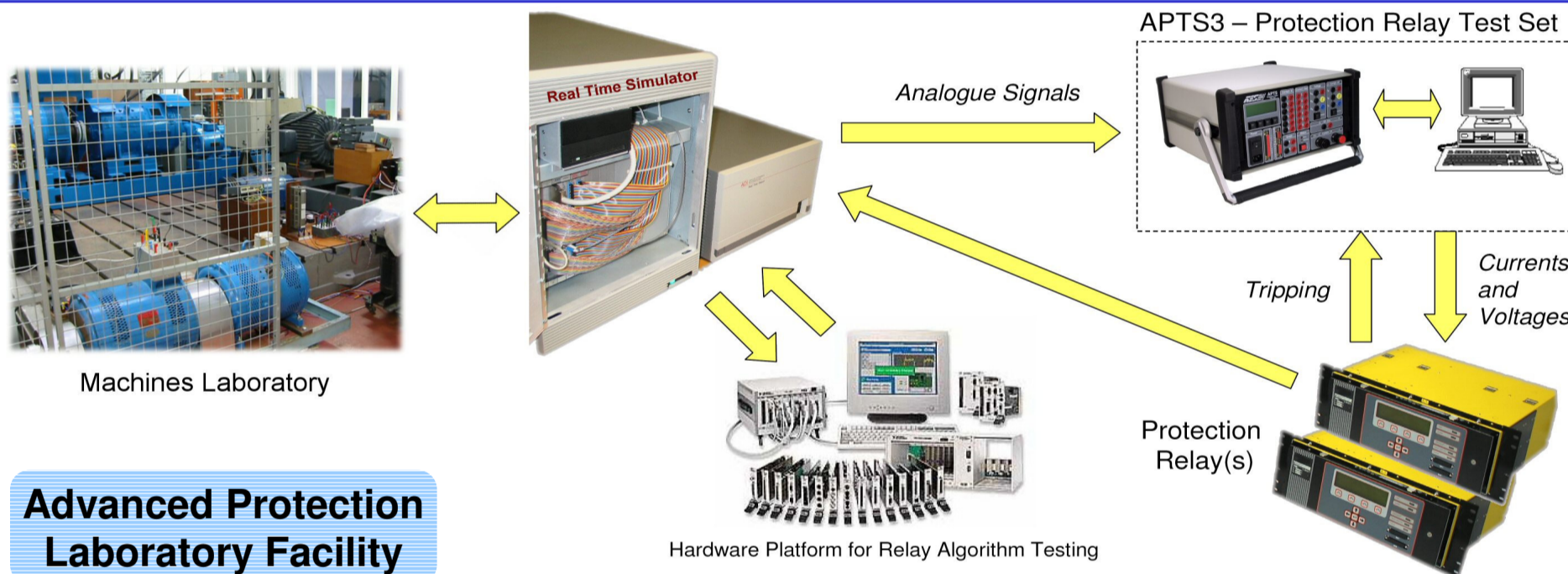
Possible Solutions: Adaptive protection, communication based unit protection.

3. Protection discrimination

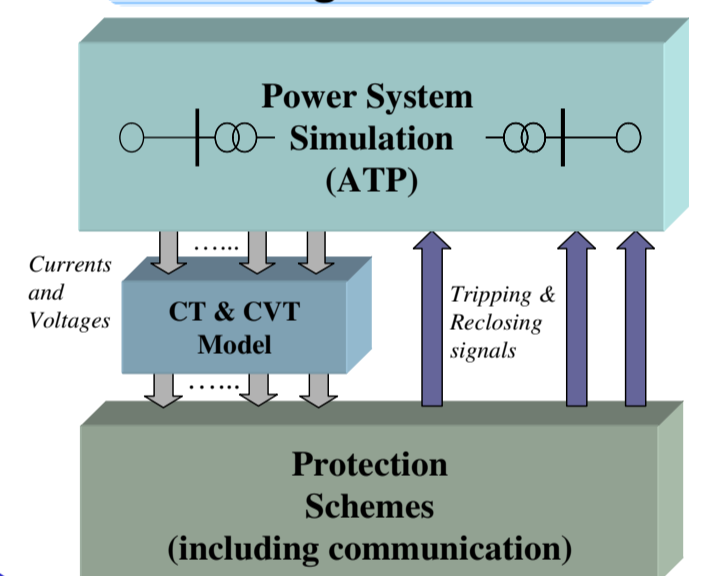
With increased levels of DG penetration (particularly at the 33kV and 11kV voltage levels), proper overall protection system discrimination is often compromised. There are existing solutions to this problem, however, investigation and research of innovative solutions would be beneficial to reduce the cost associated with existing solutions.

Possible Solutions: Improved network visibility through cost effective optical measuring methods, transmission type unit or distance protection schemes.

Software and Hardware Facilities



Protection Relay Modelling Environment



Tools for Optimal Operation and Planning of Active Distribution Networks

Overall Aims and Objectives

To assist distribution network operators and designers with optimisation of combined operation and investment of active distribution networks through balancing network reinforcement costs against cost of constraints and losses, while satisfying network voltage and thermal constraints

Tool for Optimisation of Operation of Active Distribution Networks

The tool is designed to provide new analysis capabilities in the following ways:

- Demonstrate the value of year-round, probabilistic analysis rather than selected worst-case scenarios
- Demonstrate the use of optimal power flow methods for optimising distribution networks with distributed generation (DG)
- Provide a means of assessing active management strategies and their impact on the capacity of DG that can be installed in a network. The following four main control strategies are quantified:
 - Active power generation dispatch
 - Reactive power management
 - Area based coordinated voltage control of On Load Tap Changing Transformers (OLTCs)
 - Application of voltage regulators

Tool for Planning of Active Distribution Networks

Coordination of investment and operational costs over a wide range of system conditions, calculated over a horizon of a few years, that correspond to a trade off between:

- Annualised cost of network reinforcement
- Annualised investment costs of a new compensation facilities and voltage regulators, including costs of contracts for voltage and flow regulation services delivered by generators
- Cost associated with constraining generation in order to keep network voltages and flows within allowable limits, and
- Cost of losses

The tool includes optimal scheduling of controls: active and reactive outputs of DG, taps of OLTCs, in-line voltage regulators, set voltages of reactive compensators and demand side actions.

Benefits

Quantification of benefits of optimal operation and investment of active distribution networks including:

- Increase of utilisation of existing distribution network assets
- Maximization of DG capacity that can be connected to the existing distribution network
- Simultaneous optimisation of multiple controls of OLTCs, DGs, compensation plants and demand side management
- Optimal investment and design of active distribution networks

Illustrative Example

