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Analysis of Microgrid Protection Strategies

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Discussion Topics

- Introduction
- Microgrid Architecture
- Microgrid Protection
- Adaptive Protection Scenario
- Discussion and Future work

Introduction

- Microgids have been proposed to improve reliability and stability of electrical power system and to ensure power quality of modern grid
- Microgrid protection should work for both grid connected mode and island mode
- Different protection strategies are investigated for adaptive safety protection
- FPGA based decision making is proposed for Microgrid protection to shortening response time and ensure adaptive protection

Microgrid Architecture

- Microgrid architecture include aggregation of Distributed Generator(DG), storage system which provide electric power to the loads

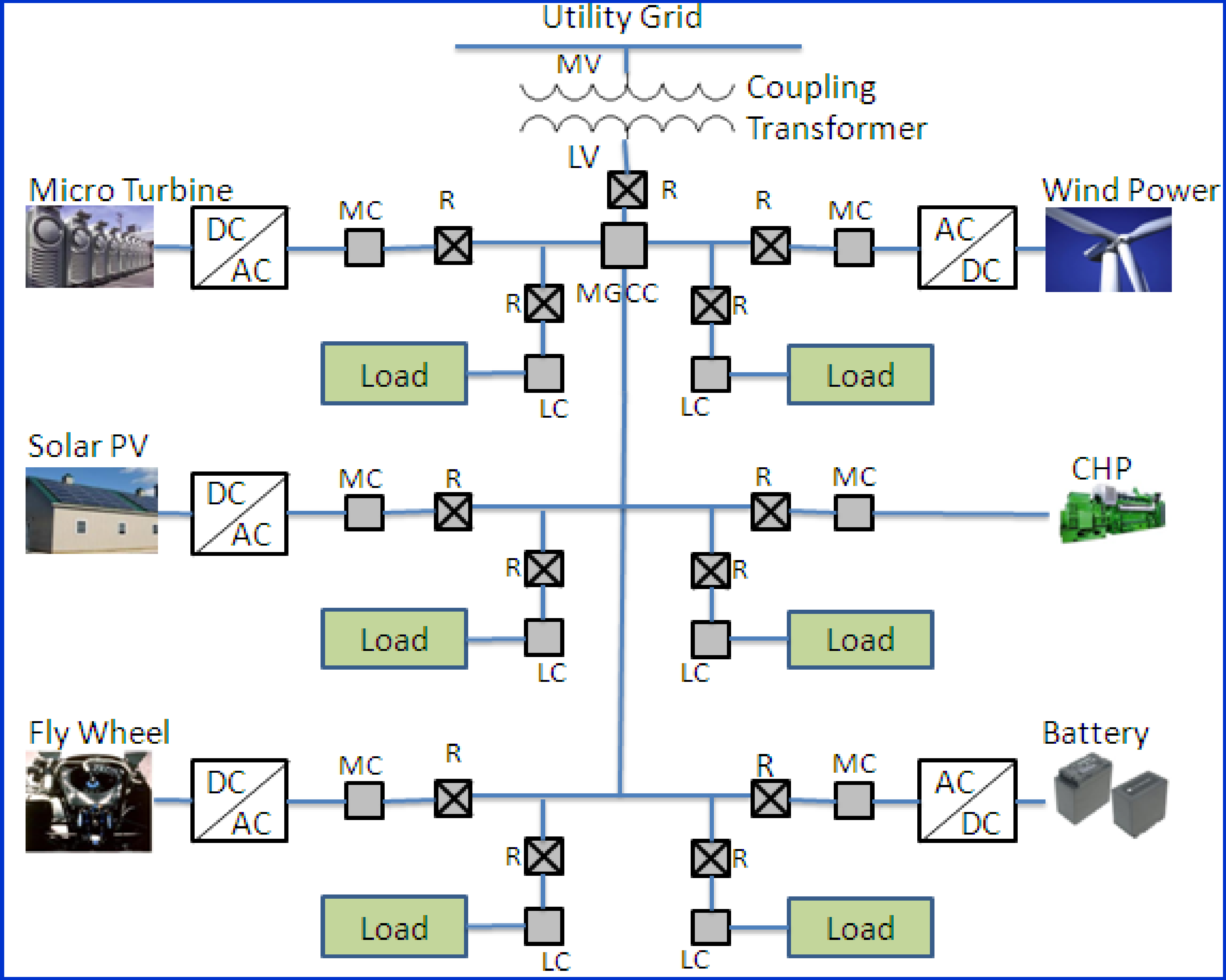
- Functional architecture include the interface, load sharing during islanding, Micro source protection, power flow control, Grid protection, control stability, and over all operation.

- Microgrid Central Controller (MGCC) is used for the upper level of the MG operation through some crucial technical & economical functions.

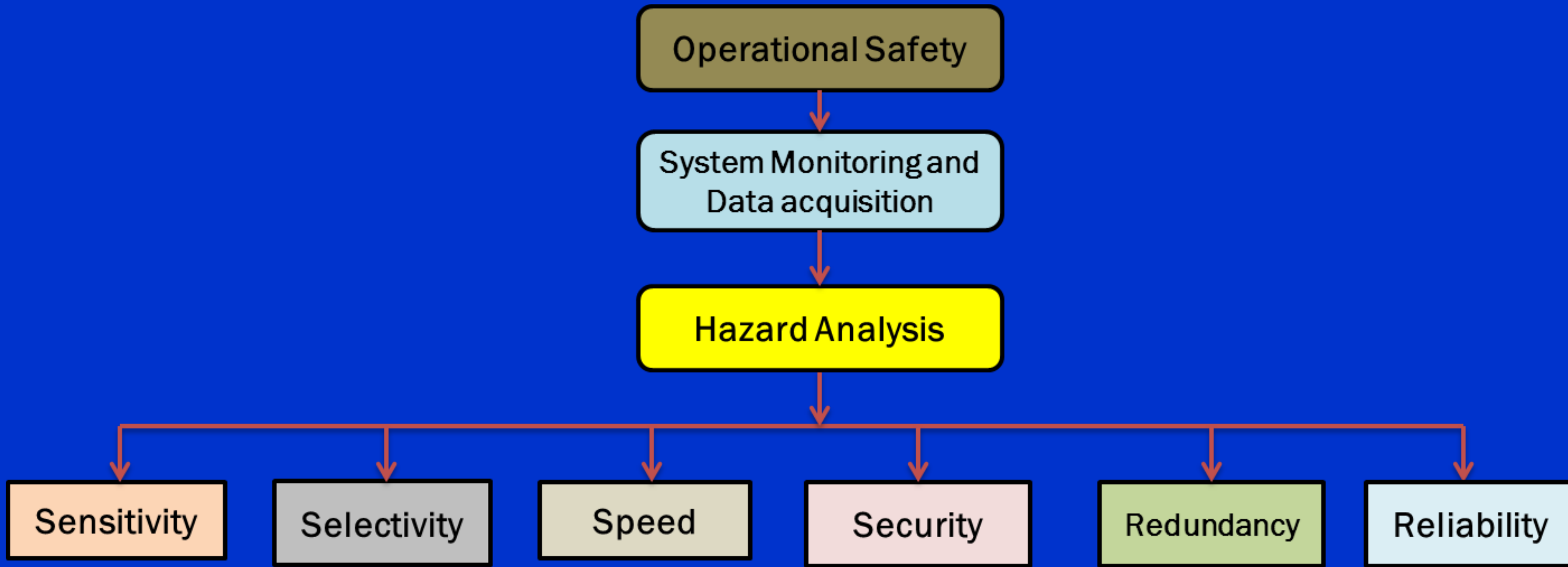
- Each Micro-source, storage devices and electrical load are locally controlled by Micro-source Controller (MC) as second hierarchical control level.

- Based on technical and economical requirement MGCC provide set point to MC and LC

Microgrid Architecture

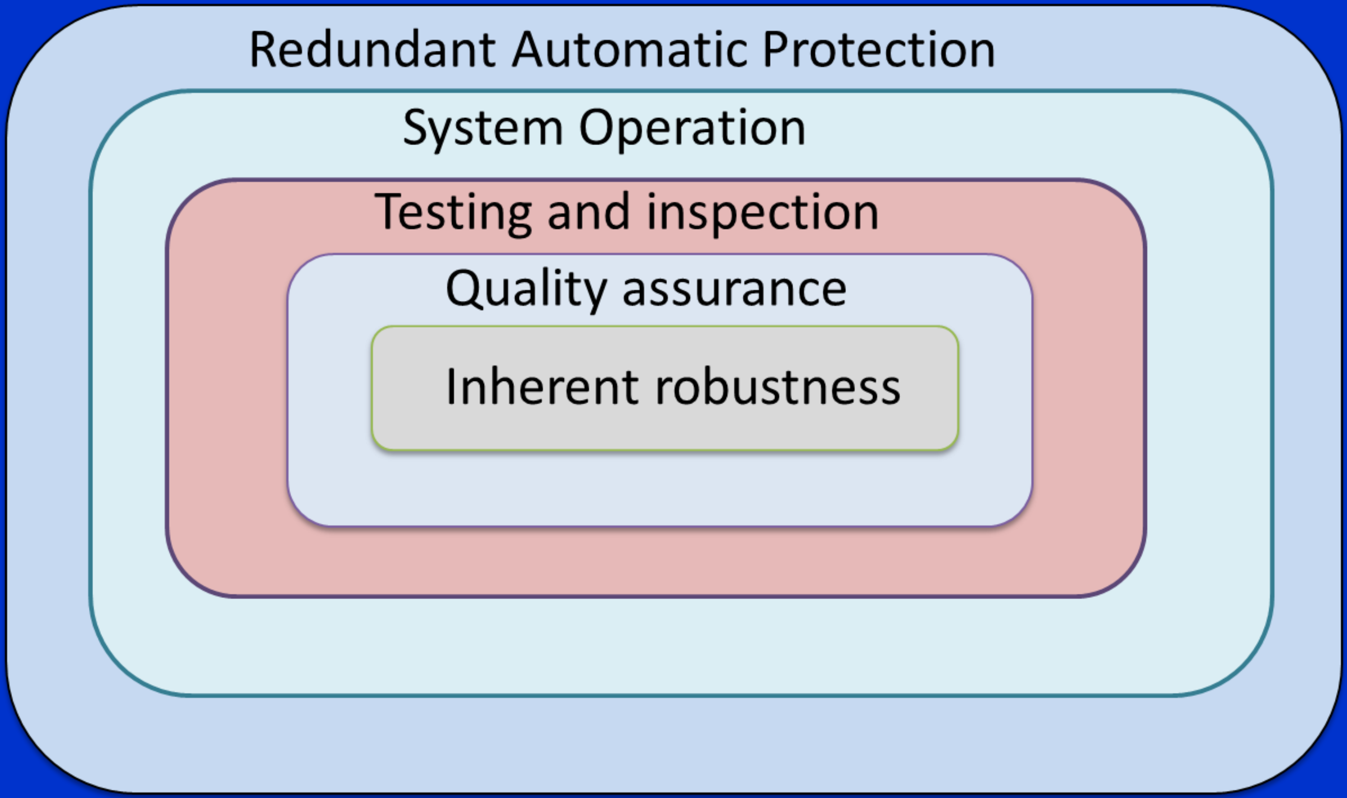


Microgrid Safety Model for Protection



- Security level should be high: protection/control system should operate only when required to operate
- Redundant system operates as backup protection to ensure higher level of safety
- Reliability: Because of dynamic structure system should have option of adaptive relay setting.

Safety Design and Protection Model

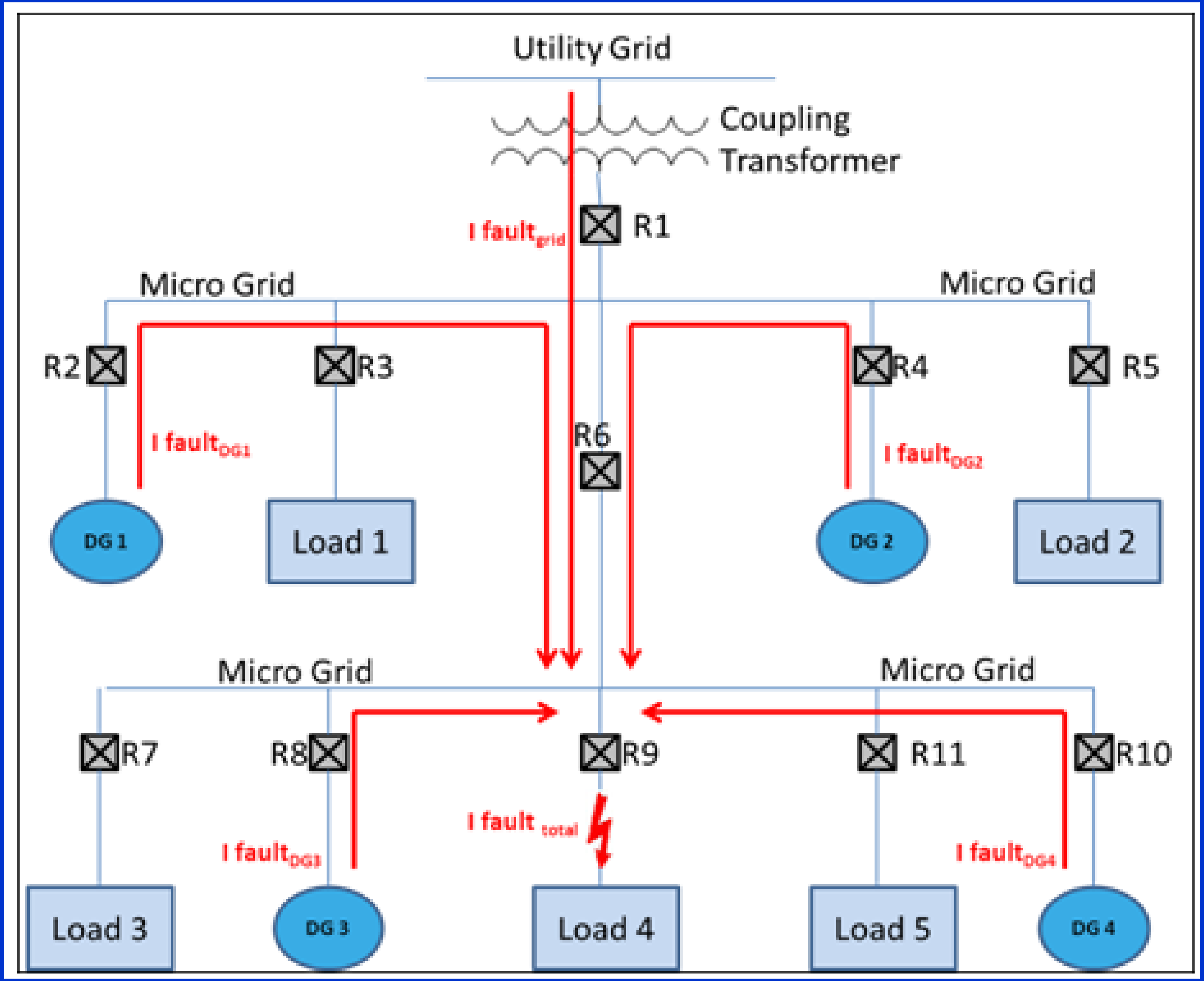


- Proper safety model provides appropriate level of confidence in protection system
- defense in depth philosophy could apply for Micro Grid safety design

Microgrid Protection Analysis

- Microgrid protection system must respond to both islanded and grid connected faults
- Modern Microgrid has been changed the conventional concept and power could flow in both direction.
- Estimation of fault current in Microgrid is not an easy task which depends in DG type and PE interface.
- To ensure safe operation of Microgrid the protection equipment should be updated accordingly

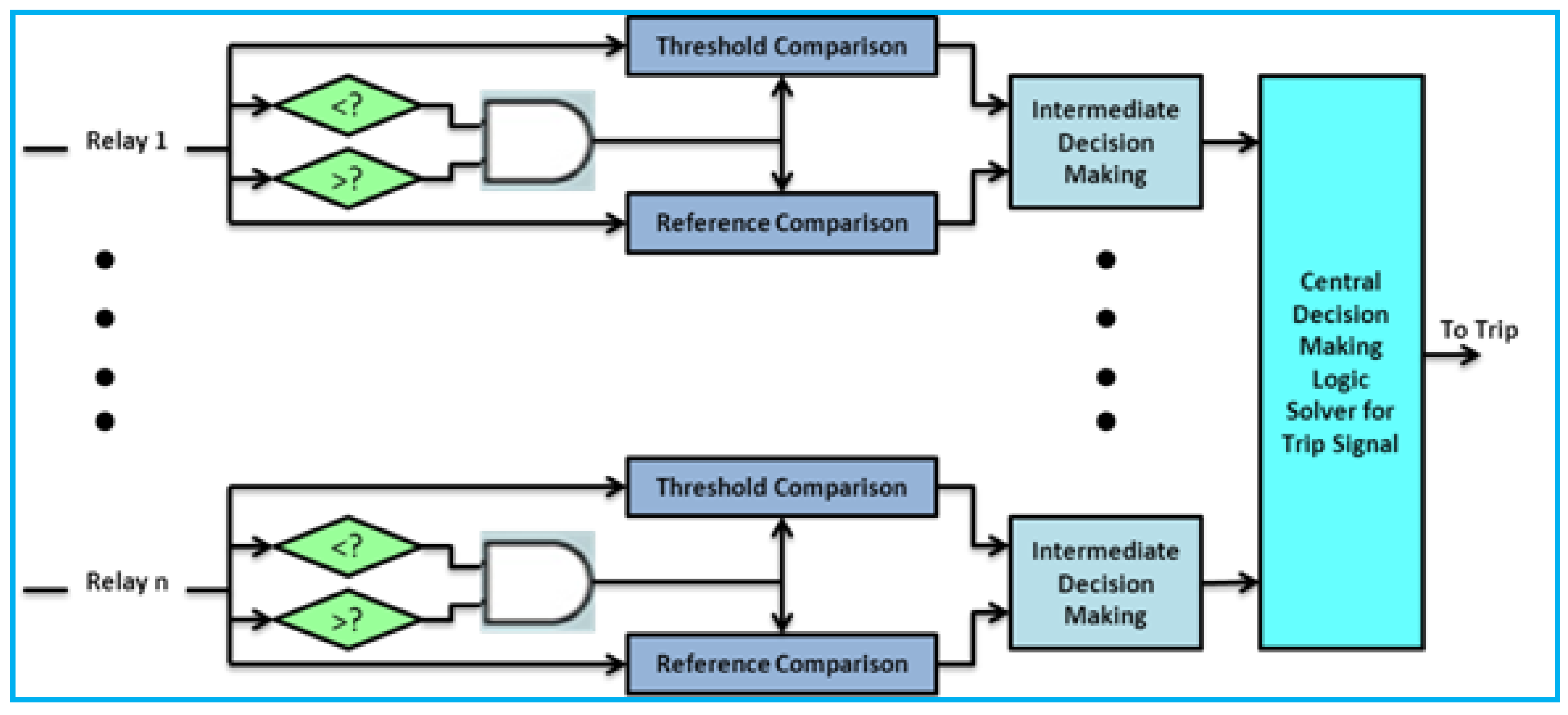
Microgrid Protection Analysis



Some of the prominent protections issues are:

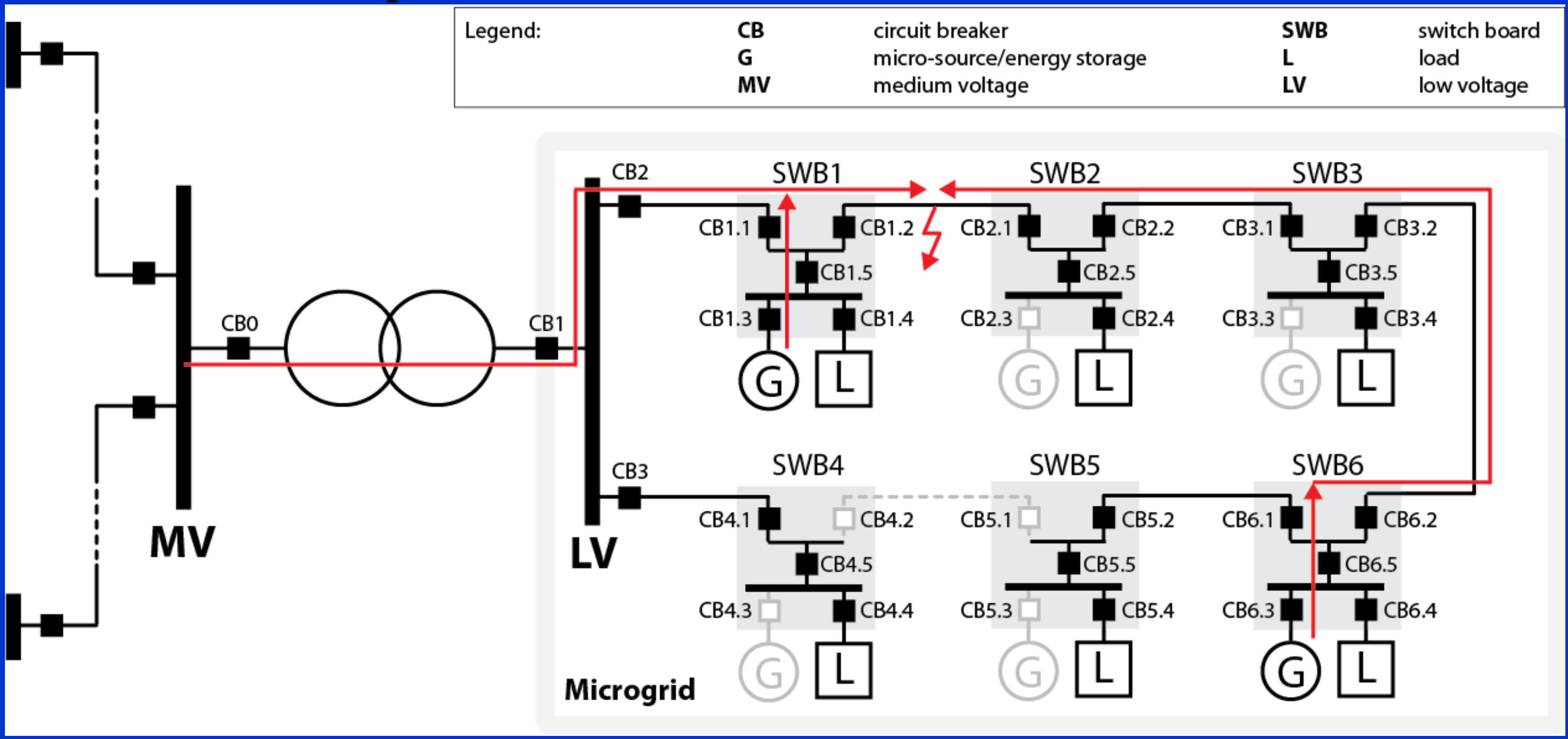
- short circuit power,
- fault current level and direction,
- device discrimination,
- reduction in reach of over-current relays,
- nuisance tripping,
- protection blinding

FPGA based Decision Making for Microgrid Protection



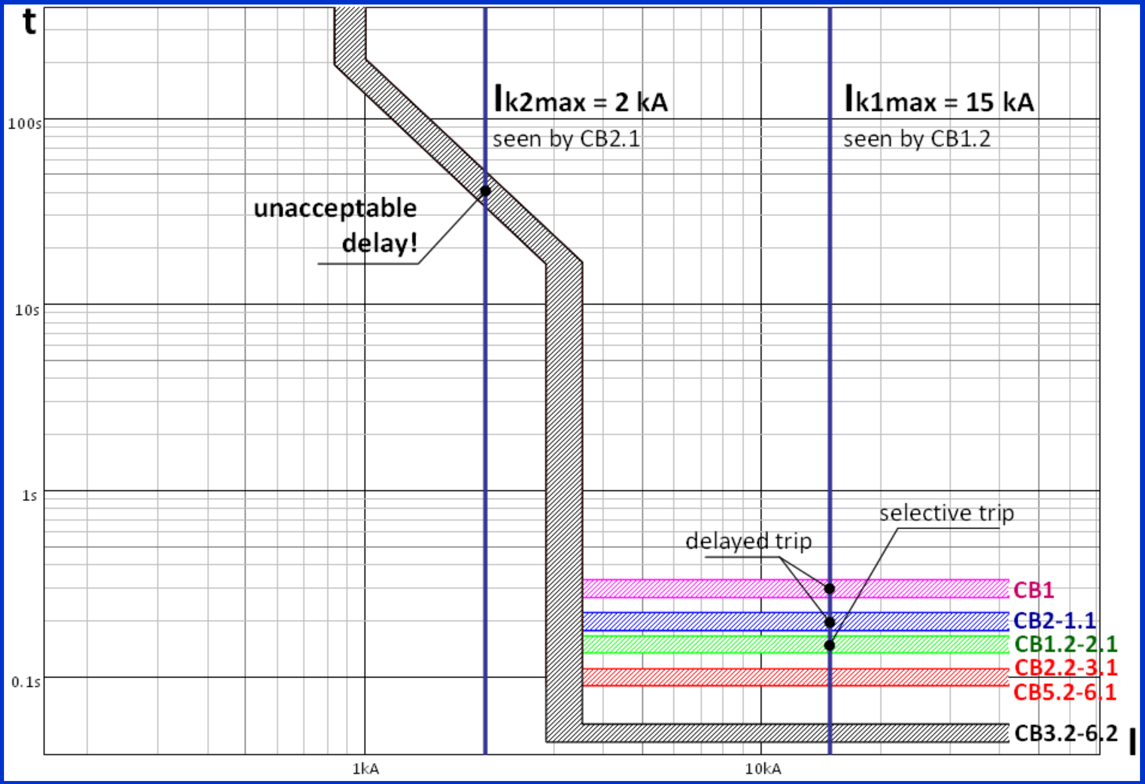
- As very complex and dynamic system, shortening fault diagnosis time one of the important matter for protection
- The logic for the relay settings basically comparison between the real-time measured process variable and trip threshold
- Modern FPGA based decision could shorten the time interval between fault occurrence and diagnostics

Adaptive Protection Scenarios



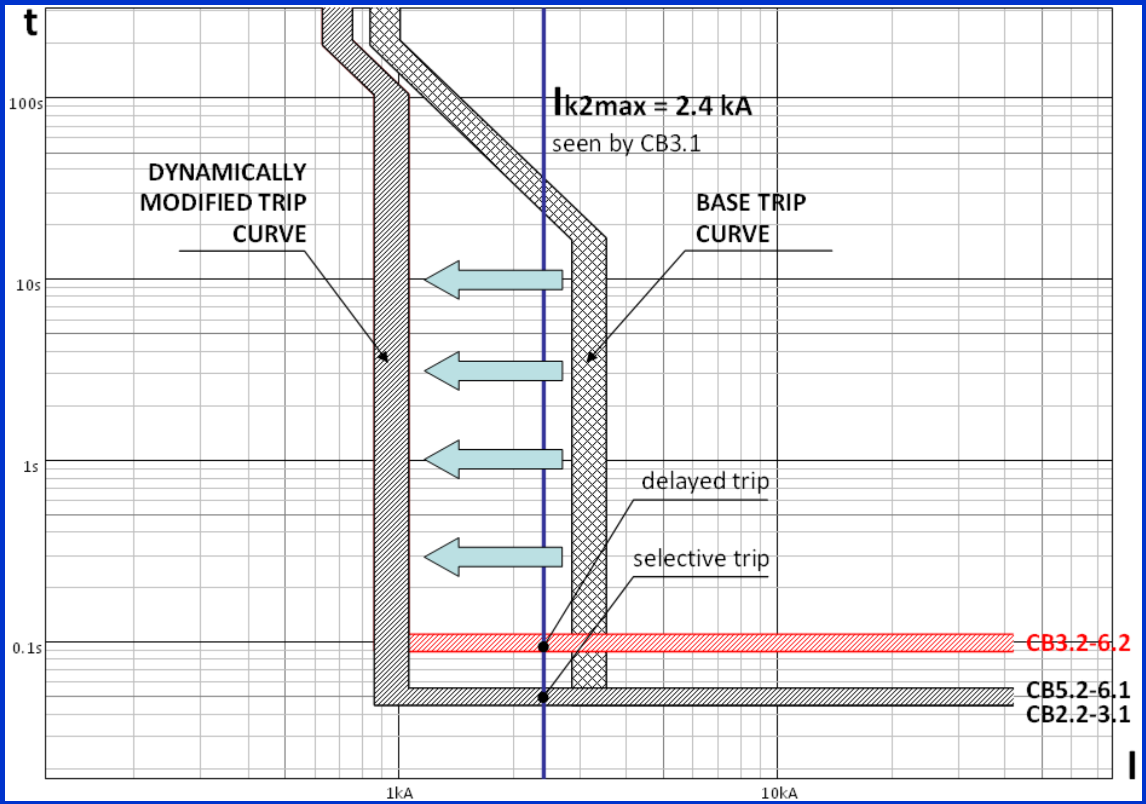
- Let assume there is a considerable change in micro grid and status of distributed energy resource.
- SWB4 and SWB5 is disconnected for a maintenance work and SWB5 and SWB6 are supplied via SWB3 (CB3.2 and CB6.2 are closed)
- Two identical distributed generators are connected with SWB1 and SWB6

Adaptive Protection Scenarios



- ❑ Now we analyze the fault between SWB1 and SWB2 (Figure 7)
- ❑ It is required to isolate the fault from the main grid side by CB1.2 and there is no selectivity and detection problem.
- ❑ Also because the fault current seen by CB1.2 becomes higher Ikmax = 15 kA (Figure) in the base case due to a contribution from the distributed resource in SWB1.
- ❑ CB2.1 is seen 2 KA fault current supplied by second distributed generator in SWB6. It can only activate the L part of the relay‘s trip curve with the expected tripping time delay of 40 s. So, by the (follow-me) function of CB1.2, CB2.1 is opened and isolates the fault from the LV feeder side in ts=150 ms .

Adaptive Protection Scenarios



- Assume in between SWB2 and SWB3 there is a second fault inside the islanded micro.
- Ideally, the fault should be cleared by CB2.2 and CB3.1. Since there is no fault current source in SWB2, CB2.2 can't trip but it can be opened by the "follow-me" function of CB3.1. In case of using directional OC protection ts = 150 ms for CB3.1.
- However, the maximum fault current supplied by the synchronous DER in SWB6 and seen by CB3.1 Ikmax=2.4 kA shown in figure.
- In island mode where the main grid does not contribute to the fault, to guarantee fast fault isolation the trip curve must be pushed to the left dynamically depending on the micro grid topology and a number of connected DG. The modified trip curves are illustrated in figure

Discussions and Future Research

- Modern numerical relay could offer several settings group which can be activated at any time.

- It can achieve instantaneous tripping in different fault and operation scenario which could be an advantage for Microgrid protection.

- Field Programmable Gate Array (FPGA) could be used for faster and corrected fault detection for Microgrid protection

- Physical implementation of FPGA based protection of Microgrid against different fault current scenario and design of new protection scheme are promising research area.

Question ?

THANK YOU!