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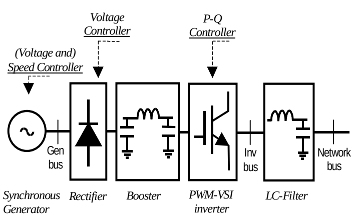
Dispersed Generators Interfaced with Distribution Systems: Dynamic Responce to Faults and Perturbations

AIM OF THE WORK

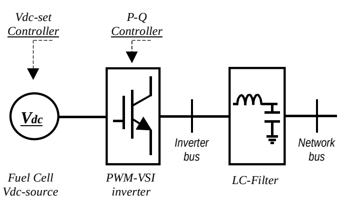
- ***Analysis of the impact of distributed generators connected to distribution networks either directly (rotating generators) or by means of power electronic interfaces (static generators).***
- ***Assessing the adequacy of the power system protections.***

DISTRIBUTED GENERATORS AND NETWORK INTERFACE MODEL

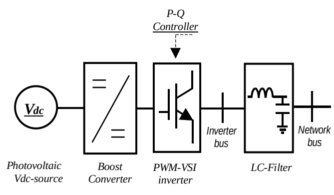
Microturbine unit model



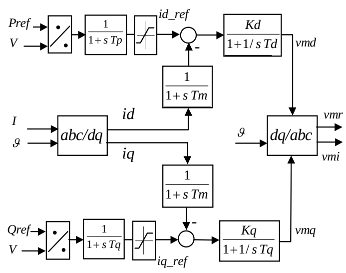
Fuel cell unit model



Photovoltaic system model



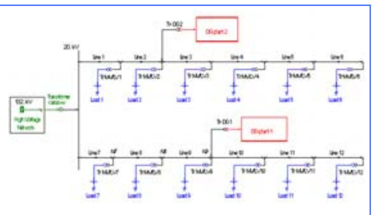
Active and reactive power controller



RESPONSE TO FAULTS AND PERTURBATIONS OF DISTRIBUTION NETWORKS INCLUDING DG

MEDIUM VOLTAGE NETWORK

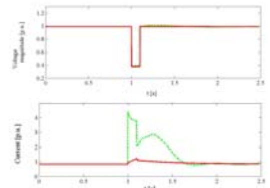
Examined system configurations:
i) two diesel units
(rotating generators);
ii) two sets of 10 microturbines
(static generators);
iii) without DG units.



THREE-PHASE SHORT CIRCUIT AT THE COMMON MEDIUM VOLTAGE BUS

SHORT CIRCUIT CURRENTS FOR CONFIGURATIONS I), II) AND III) AND RATIO BETWEEN DIFFERENT TYPES OF GENERATION CONTRIBUTION TO THE SHORT CIRCUIT CURRENT FOR TWO DIFFERENT VALUES OF THE SHORT CIRCUIT POWER

Pcc [MVA]	10^3	10^4
Fault current with rotating generators [A]	3937	4480
Fault current with static generators [A]	3827	4375
Fault current without DG units [A]	3810	4358
Rotating generation contribution / Inverter contribution	7.56	7.18



VOLTAGE AND CURRENT BEHAVIOUR AT THE MV-SIDE OF THE TRANFORMER Tr-DG1 FOR CASES I) AND II)

DG contribution to fault current and transformer stress reduced by about seven times !

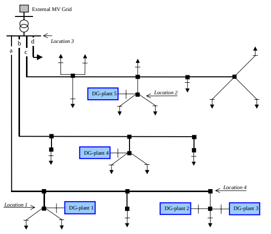
THREE-PHASE SHORT CIRCUIT AT DIFFERENT FAULT LOCATIONS

ROTATING AND STATIC GENERATOR CONTRIBUTIONS TO THE SHORT CIRCUIT CURRENT

Short circuit location	Common medium voltage bus	N7	N8	N9
Distance DG1-short circuit [km]	6	4	2	0
Rotating generator contribution [%]	2.79	2.97	3.19	3.29
Inverter generator contribution [%]	0.39	0.44	0.53	0.62
Rotating generator contribution / Inverter contribution	7.18	6.69	6.04	5.28

Advantage of static DG still significant

LOW VOLTAGE NETWORK



with five small powerful DG units:
- two microturbines;
- two fuel-cells;
- one photoltaic unit.

PHASE-NEUTRAL SHORT CIRCUIT

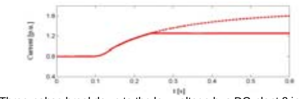
INCREASE OF THE MAXIMUM CURRENT VALUE IN THE FAULTED PHASE AT LOCATIONS 1 AND 2.

Break point	P_{DG} connected to the faulted branch [kVA]	If increase [%] (Static Dg contribution)	If increase% / kVA
Location 1	156	44.5	0.28
Location 2	22.4	24.9	1.1

THREE-PHASE SHORT CIRCUIT

DG STATIC CONTRIBUTIONS TO THE THREE-PHASE FAULTS AT LOCATIONS 3 AND 4

Fault location	Static DG Contribution [%]
Location 3	1.71
Location 4	48



Three-pahse breakdown to the low voltage bus:DG-plant 2 inverter ouput current with (solid line) and without (dashed line) current limitation.

The DG presence results in a three-phase fault current increase → ***Current reference limiters action: most protection interventions can be avoided !***

Fault location	Ig increase [%]	P_{DG} connected to other branches [kVA]
Sending end of feeder b	1.46	179
Sending end of feeder c	1.21	179

FAULT LOCATION VERY NEAR TO THE COMMON LV BUS:

INCREASES (%) OF THE OUTGOING SECONDARY STATION CURRENTS.

DG contribution to fault current of the order of about 1%.

REMARKS

- ***Negligible contribution to fault current of P-Q controlled interfaced DGs***
  - ***Possibility for many generators to be embedded without need of re-designing the feeder protection schemes***
- ***In case of static generators does not appear to exist the typical problems arising from the connection of rotating generators to distribution networks, namely increase of fault current levels and inappropriate protection device operation when there is a short circuit on an adjacent line***
  - ***It is more straightforward to guarantee the protection system selectivity***