DERri
Distributed Energy Resources
Research Infrastructures

TEMPLATE FOR PROPOSAL UNDER DERRI

User-Project Proposal:

User-Project Acronym	VC-81
User-Project Title	Detailed sensitivity and selectivity analysis of the new voltage controlled frequency function 81V introduced by the new directive 84/2012/R/EEL
Main-scientific field	Electrical power system protection
Specific-Discipline	Distributed generation protection interface

Lead User of the Proposing Team:

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Position in Organization	Protection Engineer

* Higher Education Institution (1) – Public research organization (2) – Private not-for-profit research organization (3) – Small or Medium size private enterprise (4) – Large private enterprise (5) – other (specify)

Additional Users in the Proposing Team:

Name	NA
Phone	NA
E-mail	NA
Nationality	NA
Organization name, web site and address	NA
Activity type and legal status* of Organization	NA
Position in Organization	NA

* Higher Education Institution (1) – Public research organization (2) – Private not-for-profit research organization (3) – Small or Medium size private enterprise (4) – Large private enterprise (5) – other (specify)

(Repeat for all Users)

Date of submission	21/06/2012
Re-submission	YES________ NO__X___
Proposed Host TA Facility	University of Strathclyde
Starting date (proposed)	8th October 2012

Summary of proposed research (about ½ page)

Integrating Dispersed Generation (DG) in the grid is the most important challenge of the near future for power systems in most of EU countries. Actually, DG is the only way of employ the greatest possible advantage of Renewable Energy Sources (RES) for electric production.

Distribution systems are designed for radial operation so that the power flows from upper voltage levels down to customers along the radial feeders: the presence of DG units at distribution level was not considered at the design stage. Nowadays, small DG units are currently increasing in number, as a consequence of incentives and simplification of the access to the grid. A high degree of penetration of DG has a considerable impact on operation, control, protection and reliability of the existing power systems.

The outcome of the research should define whether the 81V function can improve the selectivity of the LOM protection so that the DG can support the network during transients, with an acceptable percentage of false tripping, or if it is necessary the communication based LOM protection.

State-of-the-Art (about 1 ½ page)

The old LOM protection on the Italian power system had a very sensitive settings in terms of frequency thresholds and very fast tripping time (to allow for fast reclosure of MV lines): these characteristics will become common in all countries where power quality levels have to be guaranteed. The operation of such LOM is deemed insufficient for two main causes.

• The LOM is based on passive methods, so increasing the penetration of DG up to values such as to reach the power absorbed by loads will lead LOM to operate in the NDZ.

• Very sensitive frequency thresholds settings (49,7 Hz - 50,3 Hz, as per old CEI 0-16) lead to unwanted trips of the LOM protection, because frequency values so close to 50 Hz are possible also in operating conditions other than islanding.

Frequency transients on the transmission network have appeared on November 4th 2006 in Italy and affected the entire national transmission grid ; a significant amount of DG (about 900 MW) has been disconnected by relevant LOM protections. Also faults on adjacent feeders can lead LOM to nuisance tripping.

REFERENCES

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- Italian Electrical Committee (CEI), 2008, Technical standard CEI 0-16 “Technical

conditions for electricity distribution grid connection with a nominal voltage of greater than 1 kV", in Italian, CEI, Milan.

- CENELEC, 2005, Technical Standard IEC 61850, "Communication networks and systems in substations".

Detailed Description of proposed project : Objectives – Expected Outcome – Fundamental Scientific and Technical value and interest (2-3 pages)

REFER TO THE ABSTRACT IN ANNEX

The TA infrastructure must have the capability to simulate in real time the network model in the appendix using for example the RTDS, to create an hardware in the loop (HIL) simulation of the DG protection interface. Real time simulator, amplifiers and cabling must be provided by the TA infrastructure, while the user will provide the protection hardware.

Originality and Innovation of proposed research – Broader Impact (1-2 pages)

REFER TO THE ABSTRACT IN ANNEX

Proposed Host TA Infrastructure/Installation – Justification (about one page)

The proposed infrastructure is TA13 (University of Strathclyde) because of its capability of performing hardware in the loop real time simulations. Furthermore, the TA team has experience in this typology of testing, and therefore are the favorite TA where to perform the proposed tests in this document.

The TA user team intends to provide the protection hardware to create the HIL simulation at the TA User's expense and responsibility, while assumes that the TA will provide RTDS, two slave amplifiers and cabling.

Synergy with ongoing research (about ½ page)

During the CIRED 2011 several projects concerned the Smart Grid management. A few of them were focused in Loss of Main protection but no one recurred a basis for this new voltage controlled function.

This new project is proposing a test plan about this new and innovative rule to provide more reliability in the Loss of Main protection.

Dissemination – Exploitation of results (about ½ page)

The main goal of this project is to evaluate a real case of MV connection in case of active customer. The threshold of the protective functions will be investigated and an eventual alternative will be proposed in order to reduce the number of nuisance tripping.

Several fault cases will be simulated. For each of them a detailed sensitivity and selectivity analysis will be issued.

This project is going to be presented during a next CIRED session.

Time schedule (about ½ page)

One or two weeks during October 2012

Description of the proposing team (as long as needed)

The outcome of the research should define whether the 81V function can support the islanding condition, with an acceptable quantity of nuisance tripping, or it is strictly necessary the communication-based LOM detection methods using any intertripping scheme.

Frequency transients on the transmission network can cause a leakage of a big amount of power. Nowadays in Italy more than 12 GW is just photovoltaic power. Hence it is easily recognizable how is so important to sustain the national transmission grid in case of an event that could affect its stability.

In the early past a significant amount of DG (about 900 MW) has been disconnected improperly by relevant LOM protections, affecting the entire transmission network.

For this reason the LOM protection will be more and more a critic issue and further researches are necessary.

APPENDIX

1 INTRODUCTION

Integrating Dispersed Generation (DG) in the grid is the most important challenge of the near future for power systems in most of EU countries. Actually, DG is the only way of employ the greatest possible advantage of Renewable Energy Sources (RES) for electric production.

Distribution systems are designed for radial operation so that the power flows from upper voltage levels down to customers along the radial feeders: the presence of DG units at distribution level was not considered at the design stage. Nowadays, small DG units are currently increasing in number, as a consequence of incentives and simplification of the access to the grid. A high degree of penetration of DG has a considerable impact on operation, control, protection and reliability of the existing power systems.

2 ISSUES RELATED TO LOM PROTECTION

The use of LOM protection is common to almost all EU networks: EN 50438 collects valuable information on LOM protections[1] used in many countries, with the related settings. In particular, the codes and guidelines vary from country to country but requirements similar to the following are often given:

- DG should be disconnected in case of abnormalities in voltage or frequency;
- if one or more phases are disconnected from the grid supply, all DG units should be rapidly disconnected from the network;
- if auto-reclosing is applied, the DG units must be disconnected before reclosing, to give enough time for the fault arc to extinguish, and to avoid damages to DG units.

3 PROTECTION STRATEGIES

During the past years many methods for detecting the islanding condition have been proposed and developed. They can be divided into two categories:

1. passive methods,
2. communication-based methods.

In the first category protection is accomplished by relying solely on the local measurements (at the DG's point of common coupling PCC). The most traditional passive methods based protections, also used in the Italian electric system (national standard CEI 0-16), are based on voltage and frequency measurements:

- overvoltage (59);
- undervoltage (27);
- overfrequency (81O);
- underfrequency (81U).

Similarly 81R - Rate Of Change Of Frequency (ROCOF) and Vector Shift are well known passive protections.

However, a major drawback of all this methods is the so-called non-detection zone (NDZ). In other words, passive methods are unable to detect islanding if the power mismatch at the circuit breaker,

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[1] LOM characteristics given in the EN 50438 are common to DG units connected at MV level.

creating the island, is small. Moreover they are not able to discriminate between islanding and other events (e.g. disturbances in the HV network or fault in adjacent feeders), so the more NDZ is reduced (with more sensitive settings) the greater the number of nuisance tripping.

The second category of LOM detection methods consists of communication-based methods: in the intertripping scheme, the feeder relay located at the substation sends a trip signal to the DG units located along the feeder. For this purpose, a suitable communication channel is needed.

4 PROPOSAL OF RESEARCH

LOM protection on the Italian power system has very sensitive settings in terms of frequency thresholds and very fast tripping time (to allow the fast reclosure of MV lines[2]): these characteristics are typical of Italy, but will become common in all countries where power quality levels have to be guaranteed. The operation of such a LOM is deemed insufficient for two main causes.

- Currently LOM is based on passive methods, so increasing the penetration of DG up to values such as to reach the power absorbed by loads will lead LOM to operate in the NDZ.
- Very sensitive frequency thresholds settings (49,7 Hz - 50,3 Hz, as per CEI 0-16) lead to unwanted trips of the LOM protection, because frequency values so close to 50 Hz are possible also in operating conditions other than islanding. Frequency transients on the transmission network have appeared on November 4th 2006, and affected the entire national transmission grid[3]; a significant amount of DG (about 900 MW) has been disconnected by relevant LOM protections. Also faults on adjacent feeders can lead LOM to nuisance tripping

Nowadays the connection rules to the MV network of the active users is trying to find out an optimal solution for disconnecting the DG avoiding the great number of nuisance tripping.

The Italian Regulatory Authority for Electricity and Gas (Aeeg) has issued a new directive 84/2012/R/EEL dated 8th march 2012, with the aim of integrate the CEI 0-16 (*Reference technical rules for the connection of active and passive consumers to the HV and MV electrical networks of distribution*) with a technical document from TERNA (the Italian ISO) defining the system requirements of the DG. Hence there is a new standard de facto for connecting the DG to the grid.

What's new?

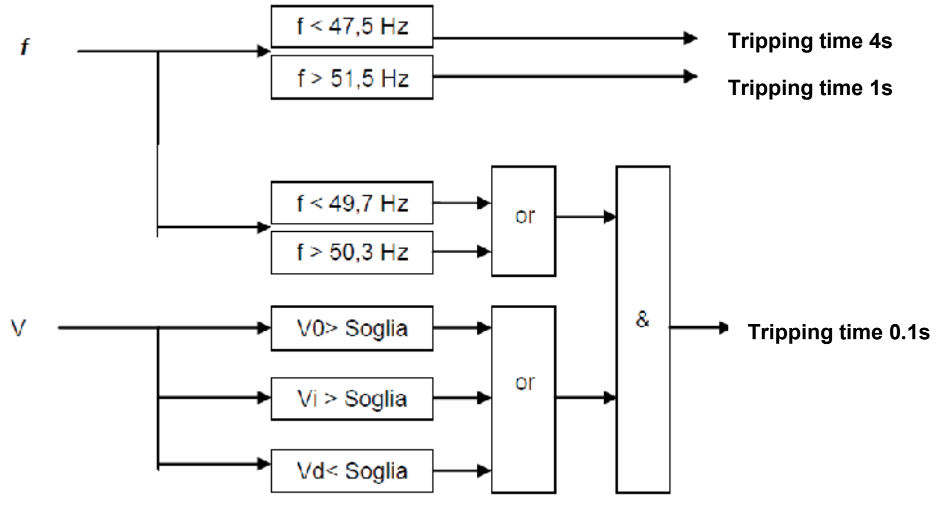
Beside the 81 O/U wide stage (47.5/51.5 Hz) there is a new restricted stage, constrained by voltage functions.

This new voltage controlled - frequency function, called 81V, is conditioned by the starting of:

a. 59N Residual Overvoltage – for detecting earth faults.
b. 59INV Negative sequence Overvoltage – for detecting asymmetric faults between phases.
c. 27DIR Positive sequence undervoltage – for detecting faults between phases.

All of them in "OR" logic.

[2] Fast reclosure (few hundred milliseconds), used only in a few EU systems, is aimed at ensuring higher levels of power quality (in case of non-permanent faults, only a transient interruption is perceived by customers).
[3] This incident, indeed, affected the whole EU electric system, causing similar DG losses in many countries.



This research is trying to investigate a sensitivity test between the threshold of the above mentioned constrains (a., b., and c.) and the tripping from the over/under frequency protective functions.

A real case will be investigated adopting a model in RTDS, simulating the single-line diagram in appendix.

Two protection relays from Thytronic, compliant to CEI 0-16 and Allegato 70, will be properly connected to the RTDS:

1. NA60 – Directional overcurrent relays – the main protection
2. NV10P – voltage/frequency relay – the LOM relay.

Two main scenarios will be simulated.

MV network internal fault – downstream the primary substation

Three points of fault. Within four different generating conditions:

1. Supplying equal to feeding – no power mismatching occurs.
2. Supplying around 20% of power to the MV network.
3. Feeding around 20% of power from the MV network.
4. Supplying 100% of power to the MV network.

Therefore 12 different cases will be reported.

HV network external fault – downstream the primary substation

A frequency transient in the HV network will be simulated.

Within this transient the LOM protection has not to operate, even if the frequency varies, because the 81V is not starting. Therefore the DG is feeding power to the network supporting its stability.

5 CONCLUSION

The outcome of the research should define whether the 81V function can improve the selectivity of the LOM protection so that the DG can support the network during transients, with an acceptable percentage of false tripping, or if it is necessary the communication based LOM protection.

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