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GRID VOLTAGE GENERATION SYSTEMS UNDER DDSRF PLL, DSOGI PLL & ISCRETE

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Abstract

In this paper, synchronization of grid voltage of the distributed generation systems was proposed by using fuzzy logic controller. In order to achieve satisfactory results with such systems, it is necessary to count on accurate and fast grid voltage synchronization algorithms, which are able to work under unbalanced and distorted conditions. This paper analyzes the synchronization capability of three advanced synchronization systems: the decoupled double synchronous reference frame phase-locked loop (PLL), the dual second order generalized integrator PLL, and the three-phase enhanced PLL, designed to work under such conditions. Although other systems based on frequency-locked loops have also been developed, PLLs have been chosen due to their link with dq 0 controllers. The simulation was done by using MATLAB/Simulink software.

Keywords: - Ddsrf pll, Dsogi pll, discrete, Discrete.

1. INTRODUCTION

In the actual grid code requirements (GCRs), special constraints for the operation of such plants under grid voltage fault conditions have gained a great importance. These requirements determine the fault boundaries among those through which a grid-connected generation system shall remain connected to the network, giving rise to specific voltage profiles that specify the depth and clearance time of the voltage sags that they must withstand Such requirements are known as low voltage ride through (LVRT) and are described by a voltage versus time characteristic. Although the LVRT requirements in the different standards are very different, as shown in, the first issue that generation systems must afford when voltage sag occurs is the limitation of their transient response, in order to avoid its protective disconnection from the network. This is the case, for instance, of fixed speed wind turbines based on squirrel cage induction generators, where the voltage drop in the stator windings can conduct the generator to an over speed tripping, as shown in. Likewise, variable speed wind power systems may lose controllability in the injection of active/reactive power due to the disconnection of the rotor side converter under such conditions. Likewise, PV systems would also be affected by the same lack of current controllability. Solutions based on the development of auxiliary systems, such as STATCOMs and dynamic voltage regulators (DVRs), have played a decisive role in enhancing the fault ride through (FRT) capability of distributed generation systems, as

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demonstrated in. Likewise, advanced control functionalities for the power converters have also been proposed. In any case, a fast detection of the fault contributes to improving the effects of these solutions; therefore, the synchronization algorithms are crucial. In certain countries, the TSOs also provide the active/reactive power pattern to be injected into the network during voltage sag; this is the case for the German E-on and the Spanish Red Electrical Espanola (REE). This trend has been followed by the rest of the TSOs; moreover, it is believed that this operation requirement will be extended, and specific demands for balanced and unbalanced sags will arise in the following versions of the grid codes worldwide. Regarding the operation of the distributed generation systems under balanced and unbalanced fault conditions, relevant contributions, such as, can be found in the literature. These solutions are based on advanced control systems that need to have accurate information of the grid voltage variables in order to work properly, something that has prompted the importance of grid synchronization algorithms. In power systems, the synchronous reference frame PLL (SRF PLL) is the most extended technique for synchronizing with three phase systems. Nevertheless, despite the fact that the performance of SRF PLL is satisfactory under balanced conditions, its response can be inadequate under unbalanced, faulty, or distorted conditions. In this paper, three improved and advanced grid synchronization systems are studied and evaluated: the decoupled double synchronous reference frame PLL (DDSRF PLL), the dual second order generalized integrator PLL (DSOGI PLL), and the three-phase enhanced PLL (3phEPLL).

2. IMPLEMENTATION

Grid synchronization specifications based on gcr

Despite the fact that the detection of the fault can be carried out with simpler algorithms, as shown in and, the importance of advanced grid synchronization systems lies in the necessity of having accurate information about the magnitude and phase of the grid voltage during the fault, in order to inject the reactive power required by the TSO. In the German standard, it is stated that voltage control must take place within 20 ms after the fault recognition, by providing a reactive current on the low voltage side of the generator transformer to at least 2% of the rated current for each percent of the voltage dip, as shown in Fig. 1. 100% reactive power delivery must be possible, if necessary

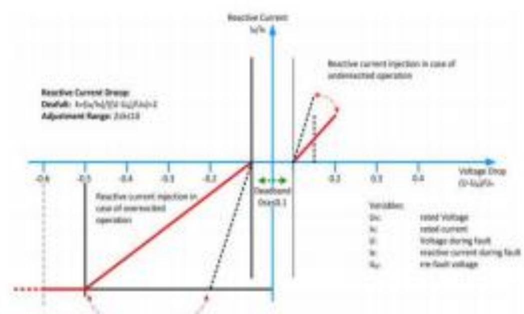

Fig:-1 E-on voltage support requirement in the event of grid fault.

A similar condition is given in the Spanish grid code, where the wind power plants are required to stop drawing inductive reactive power within 100 ms of a voltage drop and be able to inject full reactive power after 150 ms, as shown in Fig. 2. Considering these demands, this paper will consider that the estimation of the voltage conditions will be carried out within 20–25 ms, as this target permits it to fulfill the most restrictive requirements, in terms of dynamical response, available in the grid codes.

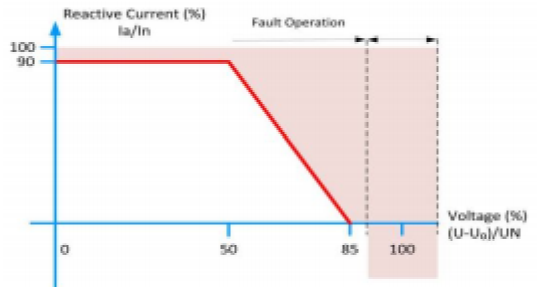

Fig:-2 REE voltage support requirement in the event of grid fault

Description of the three synchronization systems

Many authors have discussed different advanced models, which are able to overcome the problems of the classical PLL, using frequency and amplitude adaptive structures which are able to deal with unbalanced, faulty, and harmonic-polluted grids. In the framework of these topologies, three PLL structures will be discussed and evaluated in this paper.

Ddsrf pll

The DDSRF PLL, published, was developed for improving the conventional SRF PLL. This synchronization system exploits two synchronous reference frames rotating at the fundamental utility frequency, one counterclockwise and another one clockwise, in order to achieve an \ accurate detection of the positive- and negative-sequence components of the grid voltage vector when it is affected by unbalanced grid faults. The diagram of the DDSRF PLL is shown in Fig. When the three-phase grid voltage is unbalanced, the fundamental positivesequence voltage vector appears as a dc voltage on the dq + 1 axes of the positive-sequence SRF and as ac voltages at twice the fundamental utility frequency on the dq− 1 axes of the negative-sequence SRF.

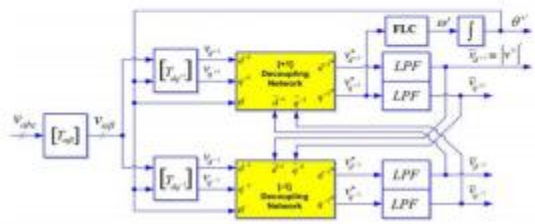

Fig:-3 DDSRF-PLL block diagram

In contrast, the negative sequence voltage vector will cause a dc component on the negative-sequence SRF and an ac oscillation on the positive sequence SRF. Since the amplitude of the oscillation on the positive-sequence SRF matches the dc level on the negative sequence SRF and vice versa, a decoupling network is applied to signals on the dq positive/negative SRF axes in order to cancel out such ac oscillations. Low-pass filters (LPFs) in Fig. 3 are responsible for extracting the dc component from the signal on the decoupled SRF axes.

Dsogi pll

The operating principle of the DSOGI PLL for estimating the positive- and negative-sequence components of the grid voltage vectors is based on using the instantaneous symmetrical component (ISC) method on the αβ stationary reference frame as explained in. The diagram of the DSOGI PLL is shown in Fig. 4. As it can be noticed, the ISC method is implemented by the positive-sequence calculation block.

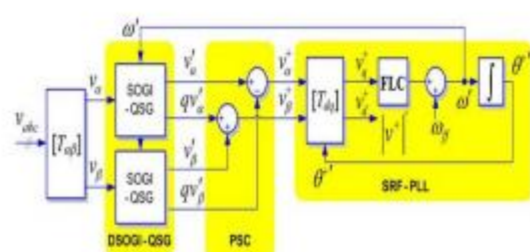

Fig:-4 DSOGI-PLL block diagram.

To apply the ISC method, it is necessary to have a set ofsignals, v α–v β, representing the input voltage vector on the αβ stationary reference

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frame together with another set of signals, qv_{α}–qv_{β}, which are in quadrature and lagged with respect to v_{α}–v_{β}. In the DSOGI PLL, the signals to be supplied to the ISC method are obtained by using a dual second order generalized integrator (DSOGI), which is an adaptive bandpass filter based on the generalized integrator concept [42]. At its output, the DSOGI provides four signals, namely, v_{α} and v_{β}, which are filtered versions of v_{α} and v_{β}, respectively, and qv_{α} and qv_{β}, which are the inquadrature versions of v_{α} and v_{β}. Computational unit. Owing to these in-quadrature signals, the instantaneous positive-sequence voltage component, v_{abc+}, can be estimated by means of using the ISC method.

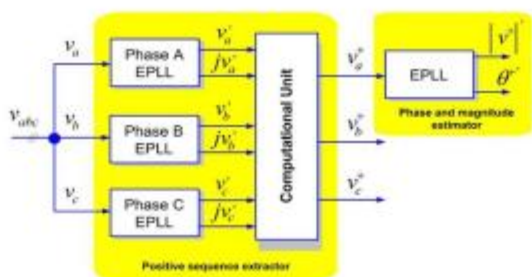

Fig:-5 3phEPLL block diagram.

Discrete

The performance of the different structures under test is really dependent on their final digital implementation, particularly on the discretization approach made to their continuous equations. This implementation is critical and should be studied in detail as a straightforward implementation can give rise to additional delays in the loop that hinder the good performance of the PLL. Some methods, such as the forward Euler, the backward Euler, and the Tustin (trapezoidal) numerical integration, offer a good performance when used for discrediting other synchronization systems, as shown. However, Euler methods can be inadequate under certain conditions, due to the need of introducing additional sample delays. Therefore, according to the specific needs of the presented topologies, this section will describe the discrete representation of each PLL individually.

3. EXPERIMENTAL RESULTS

Behavior in Case of Voltage Sags

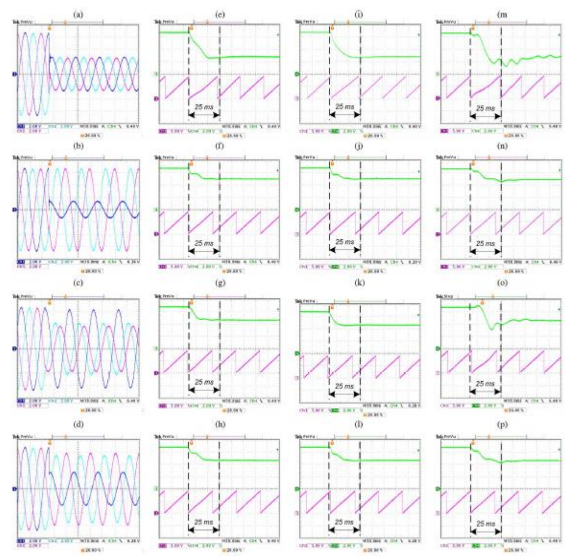

Fig: -6 Amplitude and phase estimation of the three tested PLLs in case of four types of sag

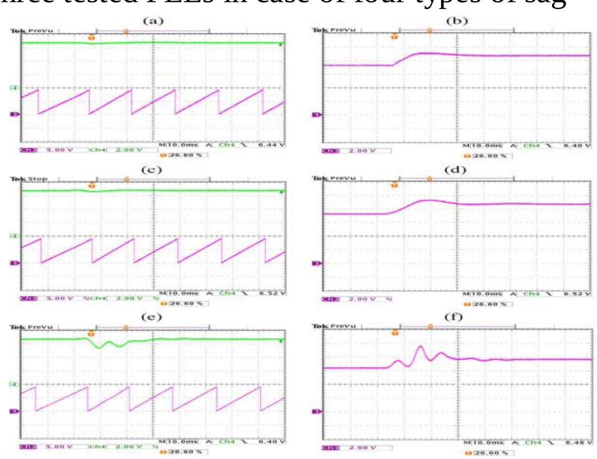

Fig:-7 Amplitude and phase estimation of the three tested PLLs in a polluted grid (THD = 8%).

4. CONCLUSION

This paper studied the behavior of three advanced grid synchronization systems by using

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fuzzy logic controller. Their structures have been presented, and their discrete algorithms have been detailed. The immunity of the analyzed PLLs in the possibility of a polluted network is better when using the 3phEPLL and the DDSRF, due to their greater band pass and low-pass filtering capabilities. Here we are using fuzzy logic controller instead of using other controllers. Although the DSOGI also gives rise to reasonably good results, due to its inherent band pass filtering structure, its response is more affected by harmonics. Although all three have been shown to be appropriate for synchronizing with the network voltage in distributed power generation applications, mainly PV and wind power, the lower computational cost of the DDSRF PLL and the DSOGI PLL, together with their robust estimation of the voltage parameters, offers a better tradeoff between the presented systems, making them particularly suitable for wind power applications. The simulation was done by using Fuzzy logic controller.

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