SYNCHRONIZATION OF GRID VOLTAGE FOR SOLAR AND WIND DISTRIBUTIVE SYSTEMS UNDER GRID FAULTS BY USING ADVANCED PHASE LOCKED LOOP TECHNIQUES

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Abstract: *With an increase in power demand usage of renewable sources plays a life-sustaining role in generating electrical power. Among renewable resources wind and solar energy are very demanding. The transmission system operators are more interested about low-voltage-ride through necessity. Solutions depends on installation of STATCOM and Dynamic Voltage Restorer(DVR) as well as advanced control functionalities for the existent power converters of distributed generation plants ,have given to improve response at distorted and faulty conditions to satisfy these requirements. To get fast and accurate grid voltage synchronization algorithmic rules under unbalanced and distorted conditions. In proposed model synchronous reference frame Phase Locked Loop (PLL), dual second order generalized integrator PLL; Three-phase enhanced PLL methods are used. Though early systems have used frequency-locked loops, PLL'S have chosen their interlink with dqo controllers. In this different algorithm rules are executed and their performance can be tested with experimental setup controlled and simulation can be done suing MATLAB or in the form of SIMULINK. The results show the effectiveness of proposed model at different algorithm rules*

Index Terms: Frequency estimation, Harmonic analysis, Electric variable measurements, Monitoring, Frequency Locked Loops, *phase locked loop.*

INTRODUCTION

Increase in penetration of technologies in electrical network strengthen the existing methods among transmission system operators their shape in grid stability. The grid considerations are becoming un-permissiveness for distributive generation systems. The grid code requirements and constraints are gained importance for these systems. These determine the fault boundaries for which the grid system remain connected to connect. These will give rise to specific voltage profiles and clearance time of voltage sag that must withstand. Such requirements are known as Low Voltage Ride Through and they are represented by voltage versus time.

In this proposed model three phase advanced grid considerations are choosen,The decoupled double synchronous reference frame PLL(DDSRF PLL),the dual second order generalized integrator PLL(DSOGI PLL),three phase enhance PLL(3ph EPLL).Their performance ,reliability of amplitude and phase detection of positive sequence voltage under distorted and unbalanced conditions. The TSO's provide active/reactive power pattern to be injected into network during voltage sag. In power systems synchronous reference frame PLL (SRF PLL) is the most extended technique for synchronizing three phase systems.

II. GRID SYNCHRONIZATION SPECIFICATIONS BASED ON GCR

The fault detection can be done using algorithmic rules 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. According to 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.

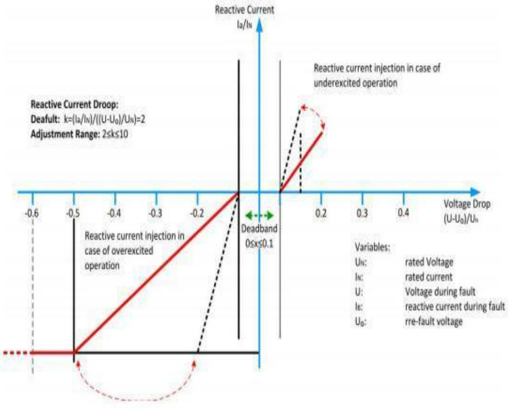


Fig. 1. E-on voltage support requirement in the event of grid fault.

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 fulfil the most restrictive requirements, in terms of dynamical response, available in the grid codes.

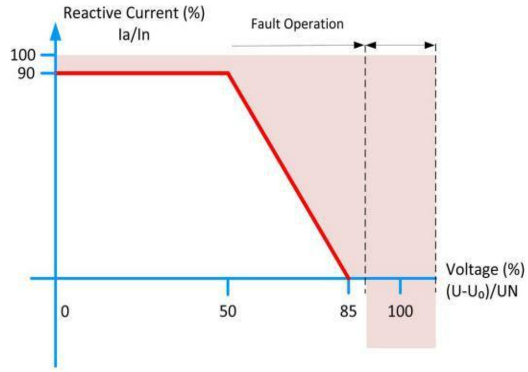


Fig. 2. REE voltage support requirement in the event of grid fault

III.DESCRIPTION OF THREE SNCHRONIZATION SYSTEMS

The positive sequence detection algorithm based on synchronous reference frame PLL (SRF PLL).Even though system is god under balanced condition the response is insufficient under faulty conditions, their operation capability is high in frequency stability which is uncongenial with the idea of full-bodied synchronization system. There are different models to overcome the problems of classical PLL using frequency and amplitude adaptive structures that deal with faulty and unbalanced conditions.

A.DDSRF PLL:

It was developed from conventional SRFPLL; three synchronization frames are rotating one in clockwise and other in anti-clockwise direction to detect positive and negative sequence voltages under unbalanced conditions.

When three phase grid voltage is unbalanced, the positive sequence voltage appears as dc voltage on dq+1 axes of positive sequence SRF and negative sequence voltage appears on dq-1 axes on negative sequence SRF.Since amplitude oscillation of positive sequence should match with negative sequence dc voltage and vice versa. A decoupling network is applied to signal on dq positive/negative axes in order to reduce ac oscillations. The components collect information about amplitude and phase angle of both positive and negative sequence components.,

Finally, the PI controller of the DDSRF PLL works on the decouple q-axis of the positive sequence of vq+1 and performs the same function in SRF PLL, Assign positive-sequence voltage with d- axis. This component is free of ac components due to decoupling network, the bandwidth of lop controller can be increased.

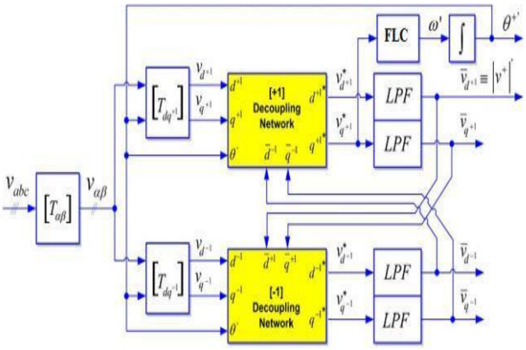


Fig. 3. DDSRF-PLL block diagram

B.DSOGI PLL

The principle of DSOGI PLL to estimate positive and negative sequence components of grid vectors is based on using instantaneous symmetrical component method on the stationary reference frame. To apply ISC method, it is necessary to have signals like Va-Vb representing the input voltage vector. In this DSOGI PPL the signals are supplied to ISC method can be obtained by DSOGI

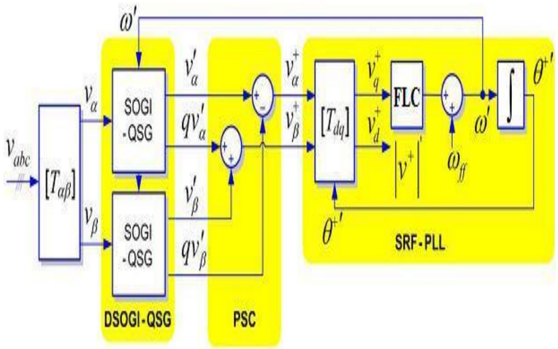


Fig. 4. DSOGI-PLL block diagram.

C.3PH ENHANCED PPL

It is a synchronization system that has good results over multiple single phase synchronization system. It is essentially a band pass filter that can be able to control cut-off frequency as a function of input signal. It can be adopted in three phase signal positive sequence obtaining 3PHEPPL is shown in fig.

In this each voltage is independently processed and filters input signal and generate two sinusoidal outputs of same amplitude and frequency V'n and jv'n the second one being

90degreeswith respect to V'n.The output result establish the input for computational input. The positive sequence voltage component V^{+abc} can be determined.

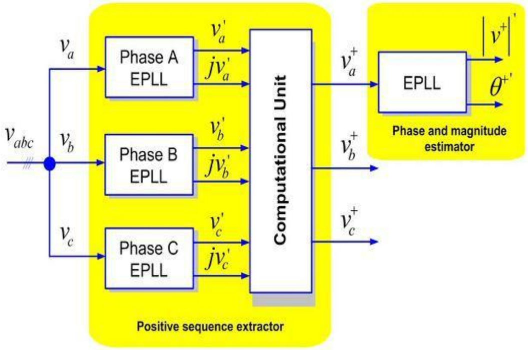


Fig. 5.3phEPLL block diagram.

IV.TESTING AND EXPERIMENTAL SETUP

The different algorithms are implemented in a control board using floating-point Texas instruments TMS320F28335 DSP at 150MHZ.The fat and accurate synchronization can be tested under faulty conditions where three phase waveforms experience transients due to voltage sag, frequency variations and harmonic pollution. Unbalanced and distorted input voltages were generated by means of ac programmable source and auxiliary transformer. Six represented faulty and distorted conditions are selected to evaluate three synchronization systems under test.

1) Type "A" Sag Test: In this voltage sag appears as a consequence of three-phase faults that give rise to high short circuit currents and to a balanced voltage drop in the network. The DDSRF PLL and the DSOGI PLL produce a good response, as both systems achieve a very fast detection (20 ms) of the positive-sequence components (less than two cycles). The response of the 3phEPLL, depicted also shows a good response, but with a larger transient in the positive-sequence estimation.

2) Type "B" Sag Test: This kind of fault permits analyzing the behaviour of the PLLs under test in the presence of zero sequence components at the input. The Clarke transformation used in DSOGI PLL and DDSRF PLL to extract the αβ components enhances the response of this synchronization system when the faulty grid voltage presents zero-sequence components. Their responses are fast and accurate. On the other hand, the 3phEPLL does not cancel out the zero-sequence component from the input voltage, something which may affect the dynamics of the positive-sequence estimation loop. However, this effect is further attenuated by the computational unit; the steady-state response is also reached with no great delay,

3) Type "C" and "D" Sag Tests: These kinds of sags appear due to phase-to-ground and phase-to-phase short circuits at the primary winding of the transformer, respectively, as. In a distribution network, these distortions are more common than the previous ones, as they are the typical grid faults caused by lightning storms. All three PLLs permit detecting the positive sequence between 20 and 30 ms; however, the 3phEPLL has a slower stabilization. This effect is a bit more noticeable with the "C" sag, where the combination of the phase jump and the magnitude change of two phases occurs.

B. Frequency Changes (50–60 Hz)

In this experiment, similar results are obtained with the DDSRF and the DSOGI PLL. The low over shooting in the amplitude estimation in both cases assists the good phase and frequency detection, Likewise, the response of the 3phEPLL shows a similar settling time; however, the initial oscillation in the amplitude estimation of the voltage contributes to slightly delay.The stabilization of the frequency magnitude, as displayed.

C. Polluted Grids (THD = 8%)

The 3phEPLL behaves as a band pass filter for the input Signal, Something that permits filtering the input without adding extra filters. The 3phEPLL offers the best filtering capability among the PLLs under test, with a clear and undistorted estimation of the magnitude and phase of the input. The response of the DDSRF PLL, which has a first-order filter at the output, is even better than the one provided by the DSOGI PLL, due to the latter's low pass filtering behavior. Although the DSOGI PLL also behaves as well as a band pass filter, the tuning of its parameters, which permits a faster stabilization of the estimated signal in the previous tests, plays against its immunity in front of harmonics giving rise to small oscillations in the positive-sequence estimation.

SIMULATION DIAGRAM

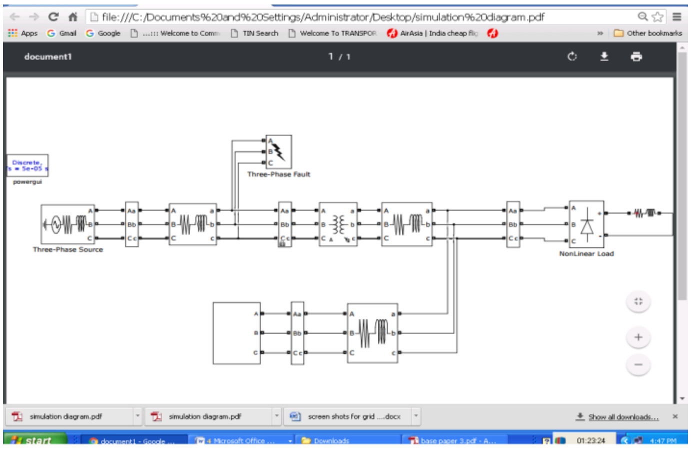


FIG.6.SIMULATION DIAGRAM OF PROPOSED SYSTEM

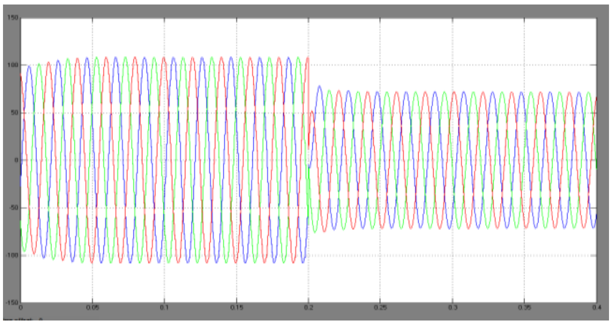


Fig.7.System Voltage under Three Phase Fault (LLLG) for DSOGI-PLL, DDSRF-PLL and 3phEPLL

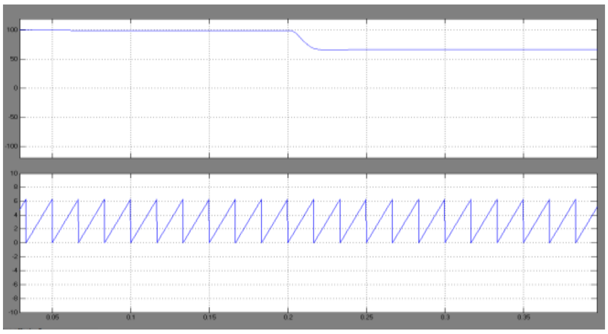


Fig.8.Voltage magnitude and Theta of the system by using DSOGI-PLL under three phase fault

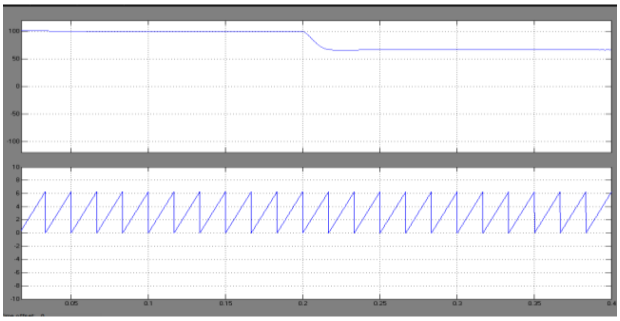


Fig.9.Voltage magnitude and Theta of the system by using 3ph EPLL under three phase fault

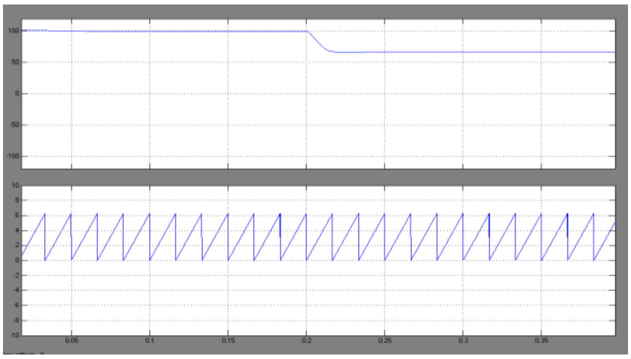


Fig.10.Voltage magnitude and Theta of the system by using DDSRF-PLL under three phase fault

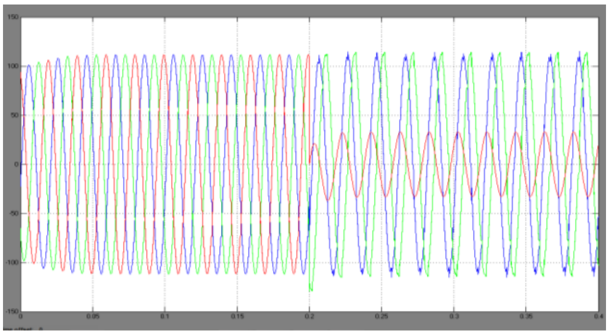


Fig.11.System voltage under Line to Ground Fault for DSOGI-PLL, DDSRF-PLL and 3phEPLL (case1)

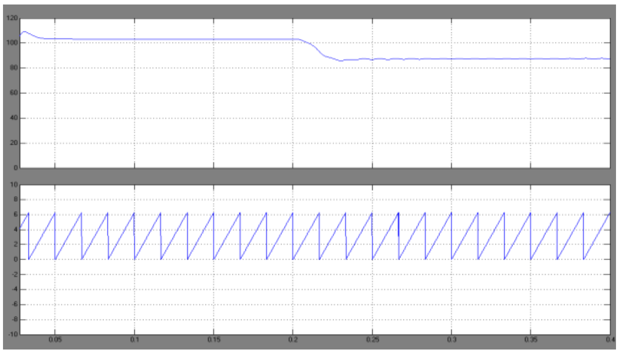


Fig.12.Voltage magnitude and Theta of the system by using 3phEPLL under Line to ground fault

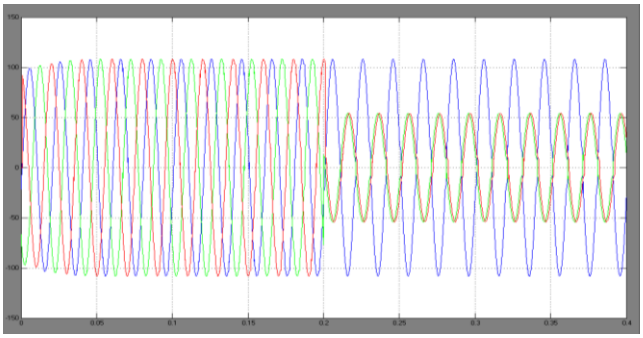


Fig.13.System voltage under Line to Line fault for DSOGI-PLL, DDSRF-PLL and 3phEPLL

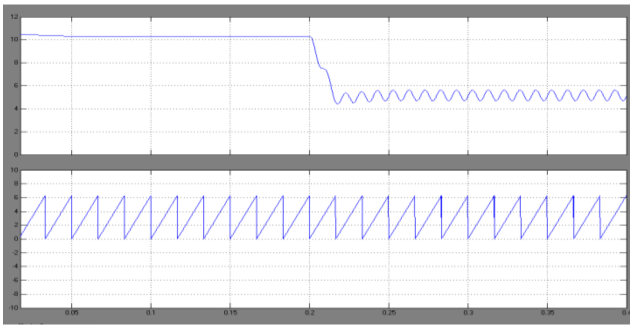


Fig.14.Voltage magnitude and Theta of the system by using DSOGI-PLL under Line to Line fault

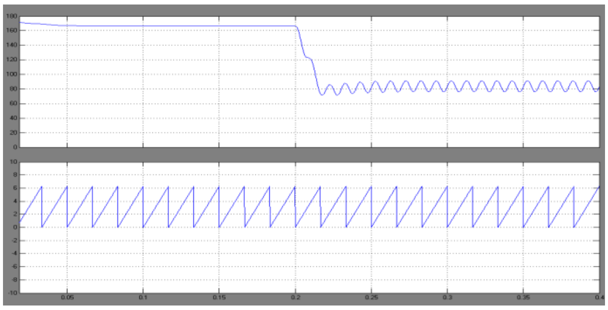


Fig.15.Voltage magnitude and Theta of the system by using DDSRF-PLL under Line to Line fault

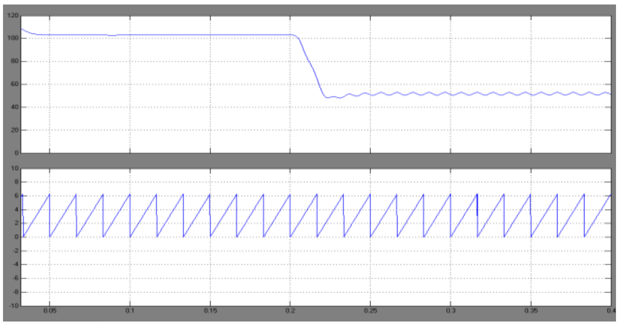


Fig.16.Voltage magnitude and Theta of the system by using 3phEPLL under Line to Line fault

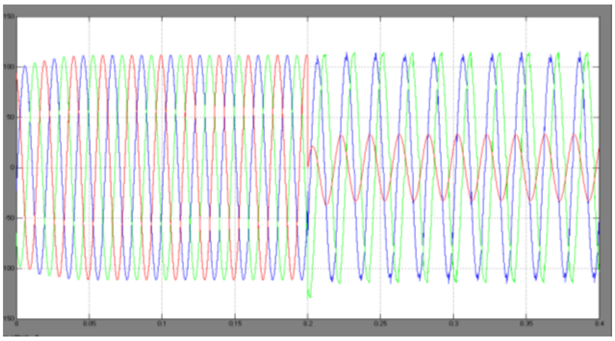


Fig.17.System Voltage under Phase to Ground Fault for DSOGI-PLL, DDSRF-PLL and 3phEPLL (case2)

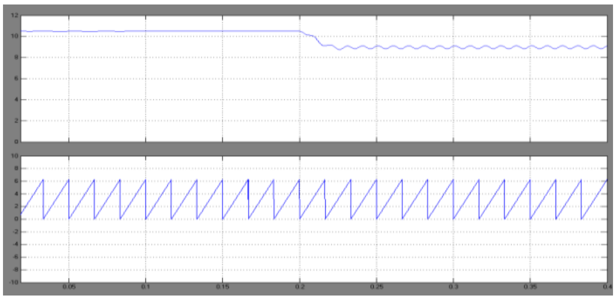


Fig.18.Voltage magnitude and Theta of the system by using DSOGI-PLL under Line to ground fault

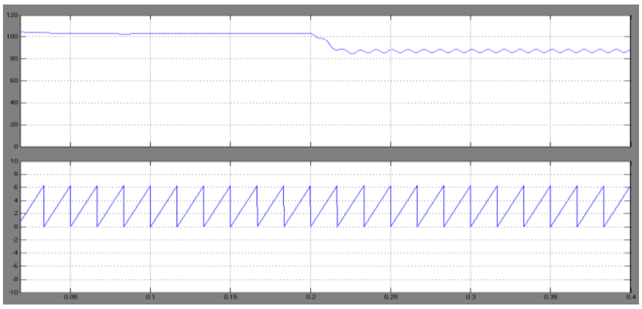


Fig.19.Voltage magnitude and Theta of the system by using DDSRF-PLL under Line to ground fault

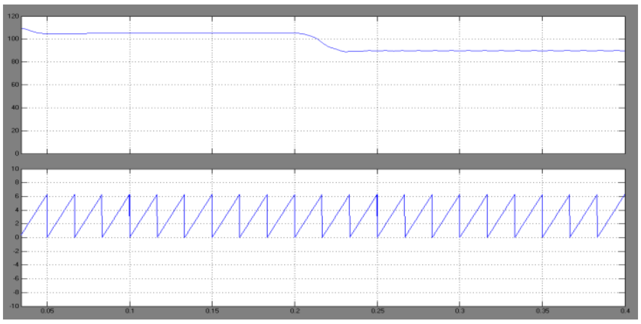


Fig.20.Voltage magnitude and Theta of the system by using 3phEPLL under Line to ground fault

Polluted Grids (THD)

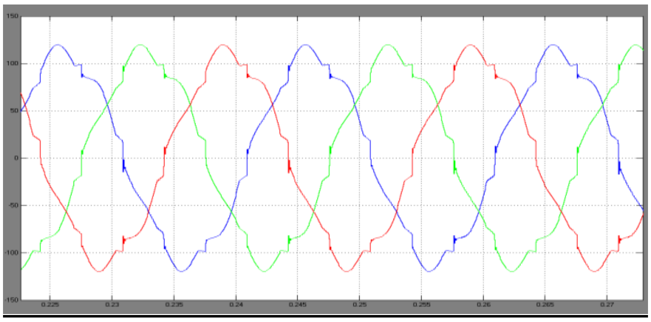


Fig.21.System voltage under polluted grid condition for DSOGI-PLL, DDSRF-PLL and 3phEPLL

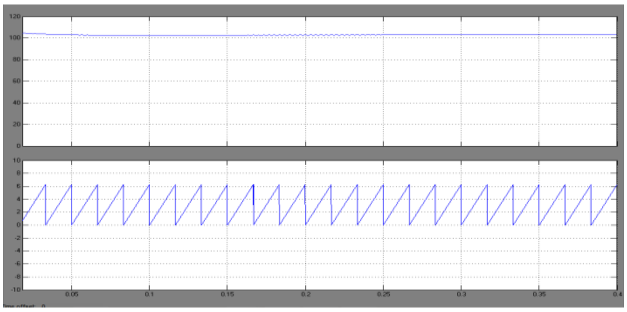


Fig.22.Voltage magnitude and Theta of the system by using DSOGI-PLL under Polluted Grid

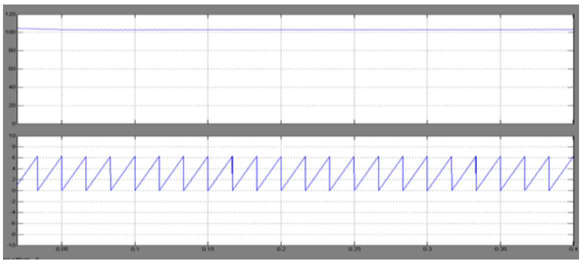


Fig.23.Voltage magnitude and Theta of the system by using DDSRF-PLL under Polluted Grid

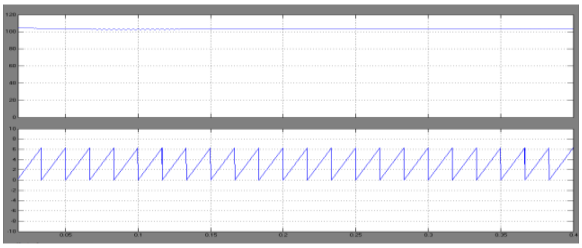
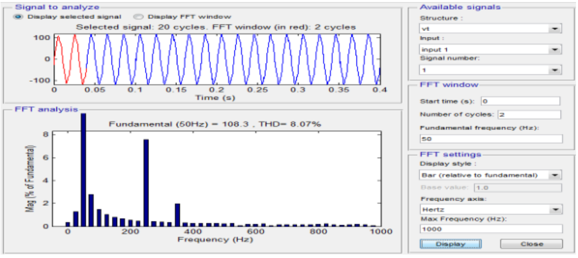


Fig.24.Voltage magnitude and Theta of the system by using 3phEPLL under Polluted Grid

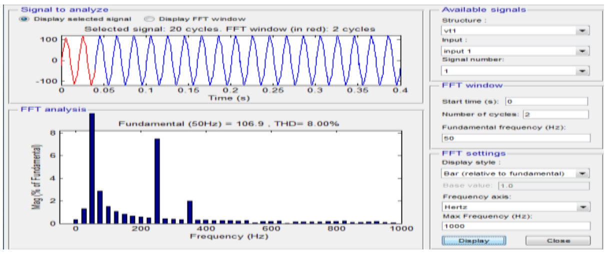


Selected signal: 20 cycles. FFT window (in red): 2 cycles

Fundamental (50Hz) = 108.3 , THD= 8.07%

Structure : vt
Input : input 1
Signal number: 1
Start time (s): 0
Number of cycles: 2
Fundamental frequency (Hz): 50
Display style : Bar (relative to fundamental)
Base value: 1.0
Frequency axis: Hertz
Max Frequency (Hz): 1000

Fig.25.Total Harmonic Distraction (THD) of polluted grid in DSOGI-PLL

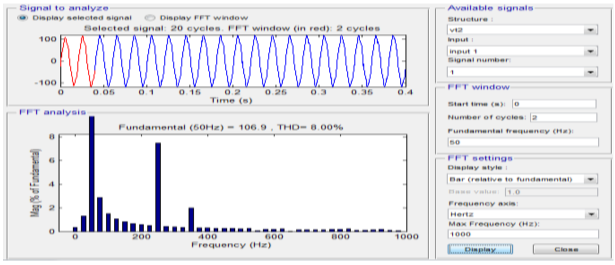


Selected signal: 20 cycles. FFT window (in red): 2 cycles

Fundamental (50Hz) = 106.9 , THD= 8.00%

Structure : vt1
Input : input 1
Signal number: 1
Start time (s): 0
Number of cycles: 2
Fundamental frequency (Hz): 50
Display style : Bar (relative to fundamental)
Base value: 1.0
Frequency axis: Hertz
Max Frequency (Hz): 1000

Fig.26.Total Harmonic Distraction (THD) of polluted grid in DDSRF-PLL



Selected signal: 20 cycles. FFT window (in red): 2 cycles

Fundamental (50Hz) = 106.9 , THD= 8.00%

Structure : vt2
Input : input 1
Signal number: 1
Start time (s): 0
Number of cycles: 2
Fundamental frequency (Hz): 50
Display style : Bar (relative to fundamental)
Base value: 1.0
Frequency axis: Hertz
Max Frequency (Hz): 1000

Fig.27.Total Harmonic Distraction (THD) of polluted grid in 3phEPLL

Frequency Changes (50–60 Hz)

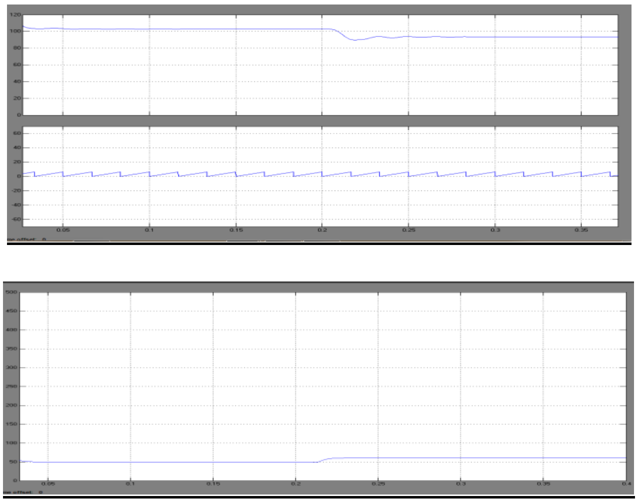


Fig.28.Amplitude, phase (rad), and frequency detection for the DSOGI PLL

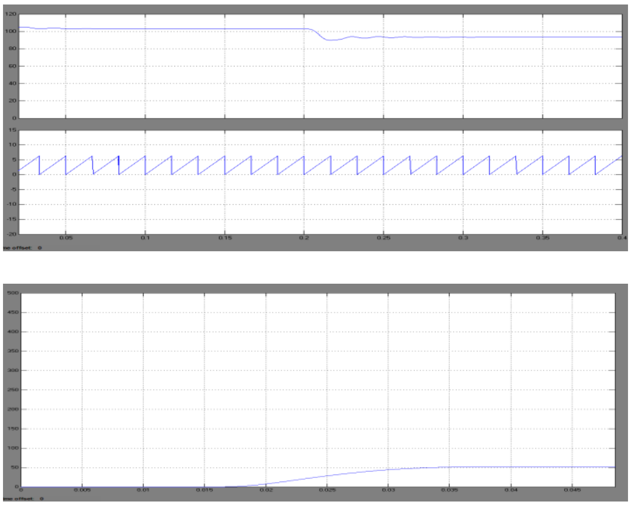


Fig.29.Amplitude, phase (rad), and frequency detection for the DDSRF PLL

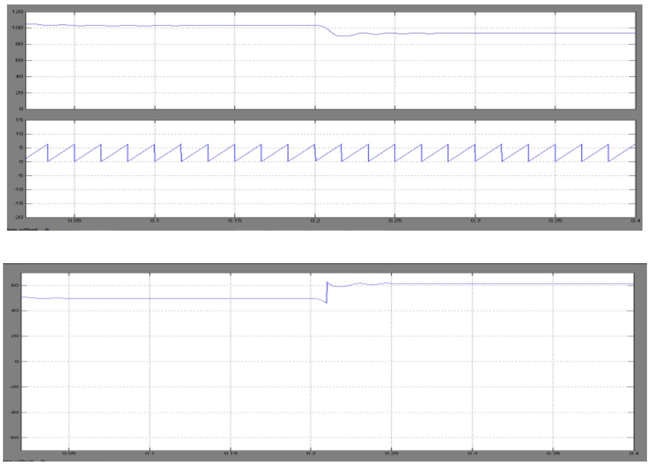


Fig.30.Amplitude, phase (rad), and frequency detection for the 3phEPLL

COMPARISON OF DDSRF, DSOGI AND 3PH EPLL

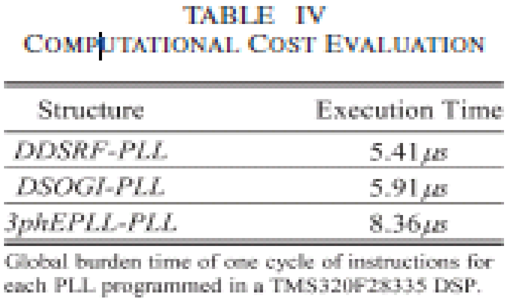


TABLE IV
COMPUTATIONAL COST EVALUATION

Structure	Execution Time
DDSRF-PLL	5.41 μs
DSOGI-PLL	5.91 μs
3phEPLL-PLL	8.36 μs

Global burden time of one cycle of instructions for each PLL programmed in a TMS320F28335 DSP.

CONCLUSION

Finally simulation done at different algorithms with advanced PLL techniques i.e,DDSRF,DSOGI,3PH EPLL.The immunity of polluted network is better when using the 3phEPLL and the DDSRF, due to their greater band pass and low-pass filtering capabilities. As DSOGI is affected by harmonics because of inherent band pass filtering structure. Because of low cost DDSRF PLL and the DSOGI PLL together with their easy estimation of the voltage parameters, offers a better tradeoff between the presented systems, making them particularly suitable for wind power applications. The simple structure of DDSRF and DSOGI are easier to tune control parameters and accurate in control of transient response.

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