

# Analysis and characterization of different three-phase PLL schemes for phase tracking under grid imperfections

**Mentor:** Prof. Dr. C. Nagamani

Pradhyumna R 107108077

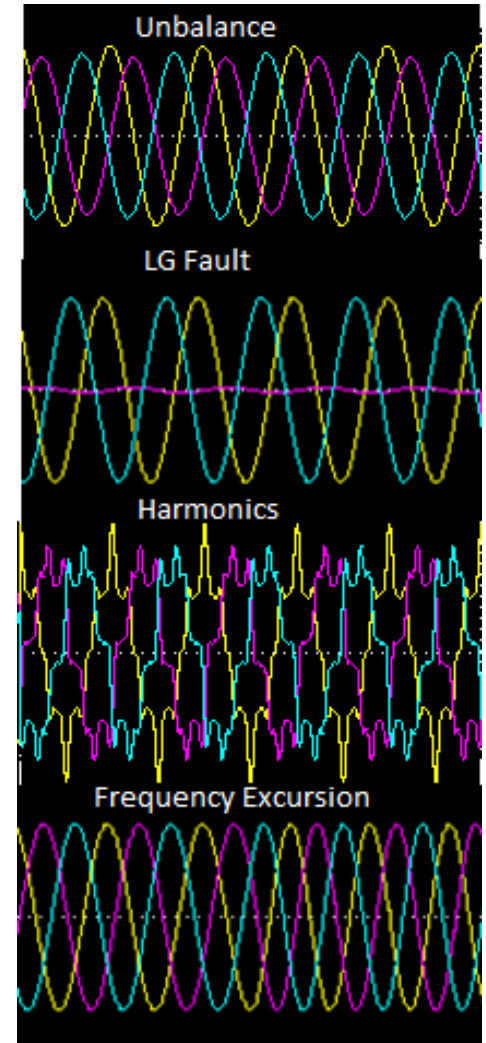
Sambhav R Jain 107108103

# Need for phase tracking

- Control of distributed generation systems
  - Synchronization between grid-interfaced converters and utility networks
  - Ride-through capability
- Control of FACTS devices  
(e.g. STATCOM, SSSC, TCR)

## Imperfections of the grid

- Balanced voltage sags, swells
- Unbalance
  - LG fault, load unbalance, load shedding
- Harmonics
- Frequency excursion



# Expectation of an ideal three phase PLL

- Ability to track accurately, the phase angle and frequency of utility voltage even under unbalanced and distorted conditions
- Ability to accurately measure the positive sequence fundamental component of the utility voltage

Analysis and characterization of the existing three-phase PLL techniques under such imperfections is to be studied

# Existing PLL methods for grid imperfections

- DDSRF – Decoupled Double Synchronous Reference Frame PLL
- MCCF – Multiple Complex Coefficient Filter based 3-phase PLL
- DSOGI – Double Second Order Generalized Integrator based 3-phase PLL
- VSPF – Variable Sampling Period Filter based 3-phase PLL (discrete PLL)

The methods listed above are some of the existing PLL methods in literature. They have been chosen for our analysis as most of the improvisations are based on them.

# Work-plan for Jan to April, 2012

- January
  - Understanding and short-listing of the existing 3-phase PLL schemes dealing with grid imperfections
- February
  - Simulations and comparisons of the same
- March
  - Design optimization and improvisation of the better schemes (based on simulation results)
- April
  - Implementation and testing of the optimized method



Thank you

## Step Frequency

Method	$\Delta\varphi_{max}$ [°]	$\Delta\varphi_{STmax}$ [°]	$\Delta f_{max}$ [Hz]	$\Delta f_{STmax}$ [Hz]
VSP-PLL	0.87	0	0.14	0
SRF-PLL	1.05	0	0.21	0
ESRF-PLL	1.51	0.45	0.21	0.01
DDSRF-PLL	1.12	0	0.24	0
DSOGI-PLL	1.44	0	0.49	0
3EPLL	2.2	0	1.2	0
VSPF-PLL	1.24	0	0.42	0

## Unbalanced Grid

Method	$\Delta\varphi_{max}$ [°]	$\Delta\varphi_{STmax}$ [°]	$\Delta f_{max}$ [Hz]	$\Delta f_{STmax}$ [Hz]
VSP-PLL	3.06	2.44	5.71	5.17
SRF-PLL	2.68	1.74	3.97	3.6
ESRF-PLL	1.71	0.46	1.91	0.03
DDSRF-PLL	2	0	2.17	0
DSOGI-PLL	2.27	0	1.77	0
3EPLL	2.7	0	2.15	0
VSPF-PLL	2.32	0	2.16	0

## Fifth Harmonic

Method	$\Delta\varphi_{max}$ [°]	$\Delta\varphi_{STmax}$ [°]	$\Delta f_{max}$ [Hz]	$\Delta f_{STmax}$ [Hz]
VSP-PLL	4.88	4.17	17.33	15.88
SRF-PLL	4.25	3.12	11.2	10.49
ESRF-PLL	2.75	1.04	6.22	5.94
DDSRF-PLL	2.63	1.75	7.35	6.82
DSOGI-PLL	2	0.74	3.67	2.82
3EPLL	1.79	0.75	4.17	3.46
VSPF-PLL	1.58	0	3.54	0

**Ref:** Variable Sampling Period Filter PLL for Distorted Three-Phase Systems by Ignacio Carugati, Sebastian Maestri, Patricio G. Donato, Daniel Carrica