# Investigation of Various Levels of Cascade Multi-Level Inverter DVR for Improve Power Quality of Induction Motor

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# OBJECTIVES

- Main objectives of work is to improve the power quality factors in induction motor drives.

- The Power quality factors such that Sags, Swells, Interruptions, Under voltage, Overvoltage, and Harmonics.

- The ‘Behavior’ of an Induction Motor is examined and using ‘Dynamic Voltage Restorer(DVR)’ improve the power quality factors in induction motor drives.

# Literature Review

Voltage disturbances are the most common power quality (PQ) problem in low voltage distribution systems. The voltage disturbances mainly encompass the voltage sags, swells, harmonics, unbalances, and flickers [2].

These voltage disturbances can cause the malfunction of voltage-sensitive loads in factories, buildings, hospitals and sever process disruptions resulting in substantial economic and/or data losses [3].

Voltage sag is normally caused by the startup of large ratings induction motors, short-circuit faults, such as a single-line-to-ground (SLG)fault in a power system and [4-6].

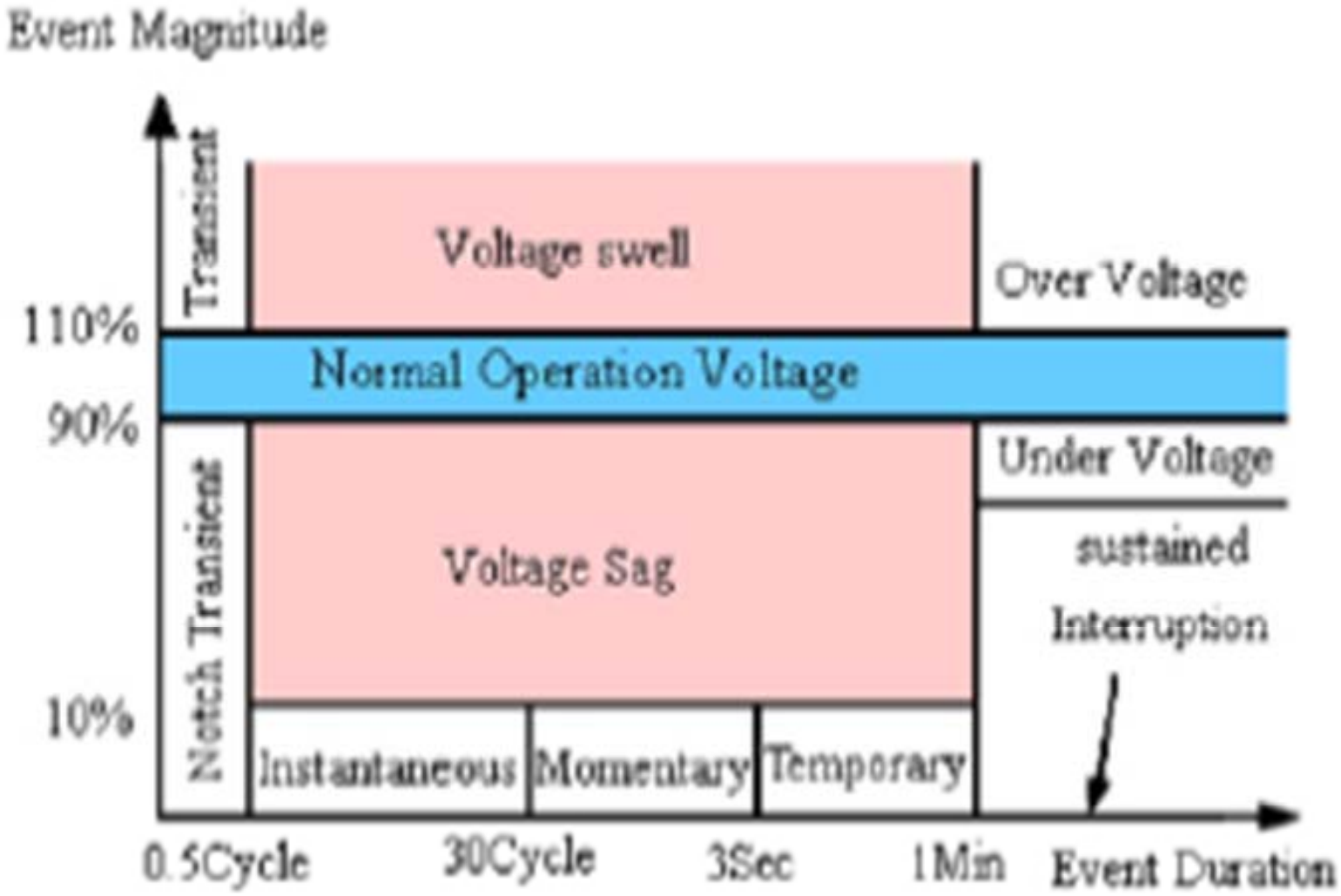
Voltage swell is defined as a short duration increase in rms supply with an increase in voltage ranging from 1.1 p.u. to 1.8 p.u. of nominal supply. The main reasons for voltage swells are switching large capacitors or the removal of large loads [7],[8].

The basic operation of DVR is to inject a voltage of required magnitude, phase angle, and frequency in series with a supply line to maintain the desired amplitude and waveform for load voltage even when the voltage is unbalanced or distorted [9], [10].

# Power Quality Problems

- It include all possible situations in which the waveforms of the supply voltage or load current deviate from the sinusoidal waveform at rated frequency with amplitude corresponding to the rated rms value for all three phases of a three-phase system.
- According to the summary of *P1159 Terms* Power quality disturbance covers transients, short-duration variations, long-duration variations, voltage imbalance, waveform distortion, voltage fluctuations and power frequency variations.

# IEEE Standard 1159- 1995



# Effect of voltage SAG&SWELL on Induction Motor

- Supply voltage to the induction motor decreases, the motor speed also decreases. If Fail to recover the normal voltage amplitude motor may stall.

- Due to ‘SAG’ , Reduce the motor torque proportional to the square of the motor terminal voltage.($T \alpha V^2$).

- Due to ‘SWELL’ and ‘SAG’ condition motor may accelerate and slows down the speed.

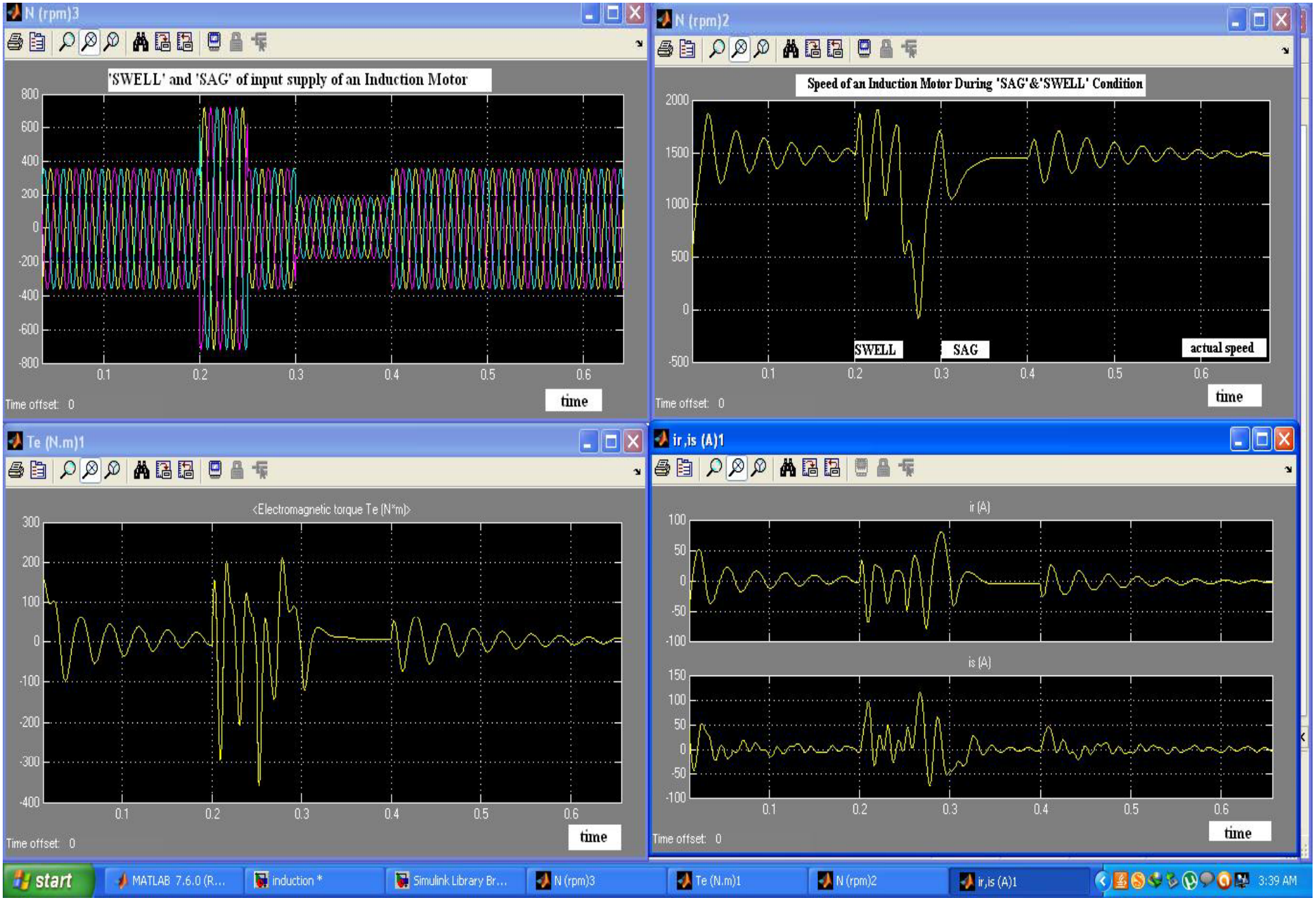
# Effects of Power Quality Problems in Induction Motor

| Power quality Issue | Effect |
|---|---|
| Over Voltage | Overstress insulation (Expected life shortening) |
| Under Voltage | Excessive $I_m$( low speed & Over Heating) |
| Unbalance | Motor Heating(Core losses) |
| Impulse Surges | Insulation Damages |
| Short Interruptions | Mechanical Shock & Possible to stall |
| Voltage ‘SAG’ | Torque, power, Speed and possible to stall |
| Voltage ’SWELL’ | Insulation Damages |
| Harmonics | Core loss& Insulation Damages |

# Solution of Power Quality Problems

| Mitigation of Voltage Dips and Short Interruption | Flicker Mitigation | Harmonic Mitigation |
|---|---|---|
| Dynamic Voltage Restorer (DVR) | Static Var Compensator | Active Filter |
| Static Series Compensator | D-Statcom | Passive Filter |
| Motor-Generator set | | Multi-Pulse Configuration |

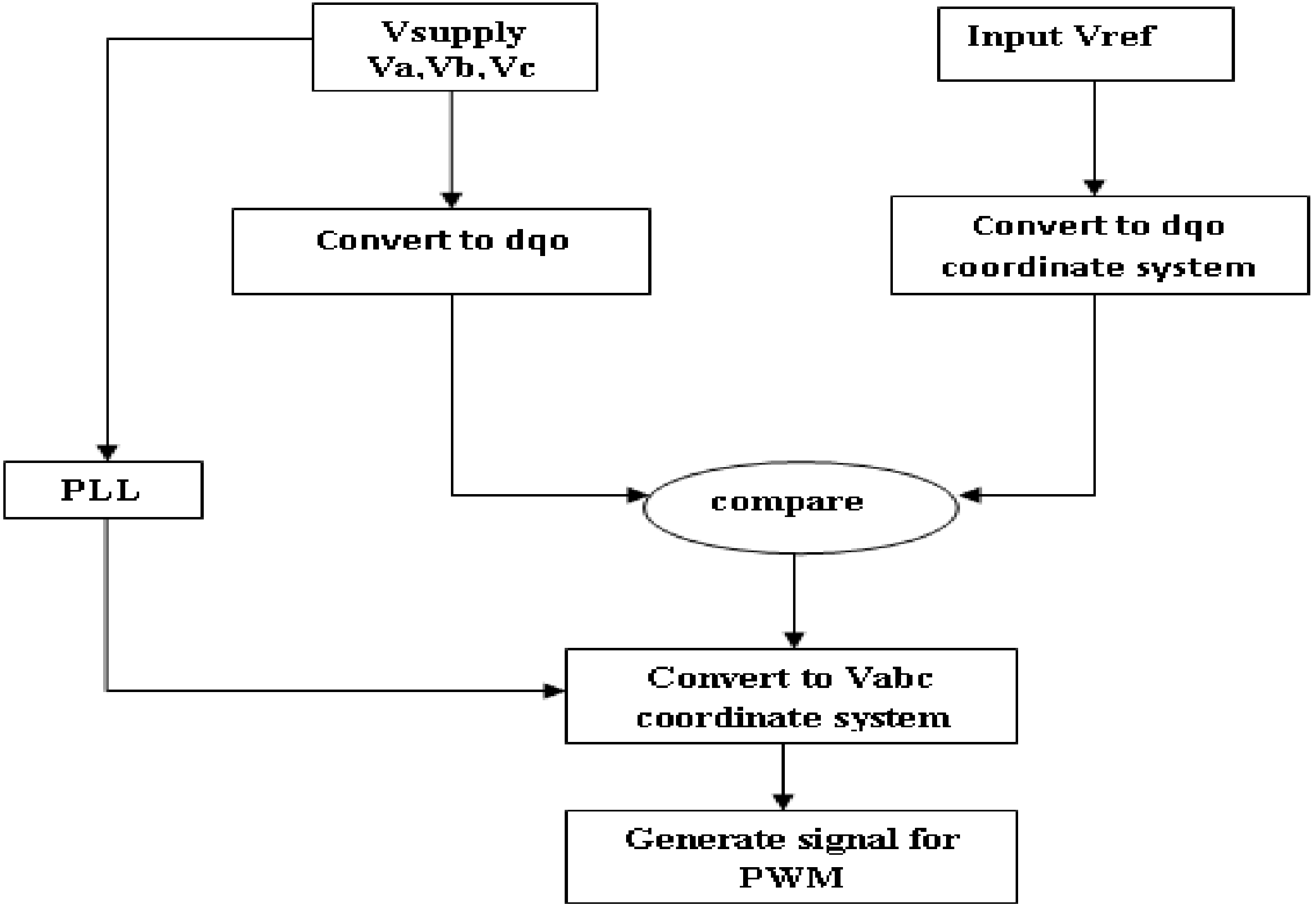
# Behavior of an ‘Induction Motor’



# About DVR (Dynamic Voltage Restorer )

- The Dynamic Voltage Restorer (DVR) has become popular as a cost effective solution for the protection of sensitive loads from voltage ‘SAG’ and ‘SWELL’.
- The control of the compensation voltages in DVR based on dqo algorithm is discussed.
- The effects of power quality as well as enhancing this power quality in distribution network, using FACTS (Flexible AC Transmission System) Devices.
- DVR is a powerful custom power device for short-duration voltage compensation, which is connected in series with the load & hence it possesses some advantages.

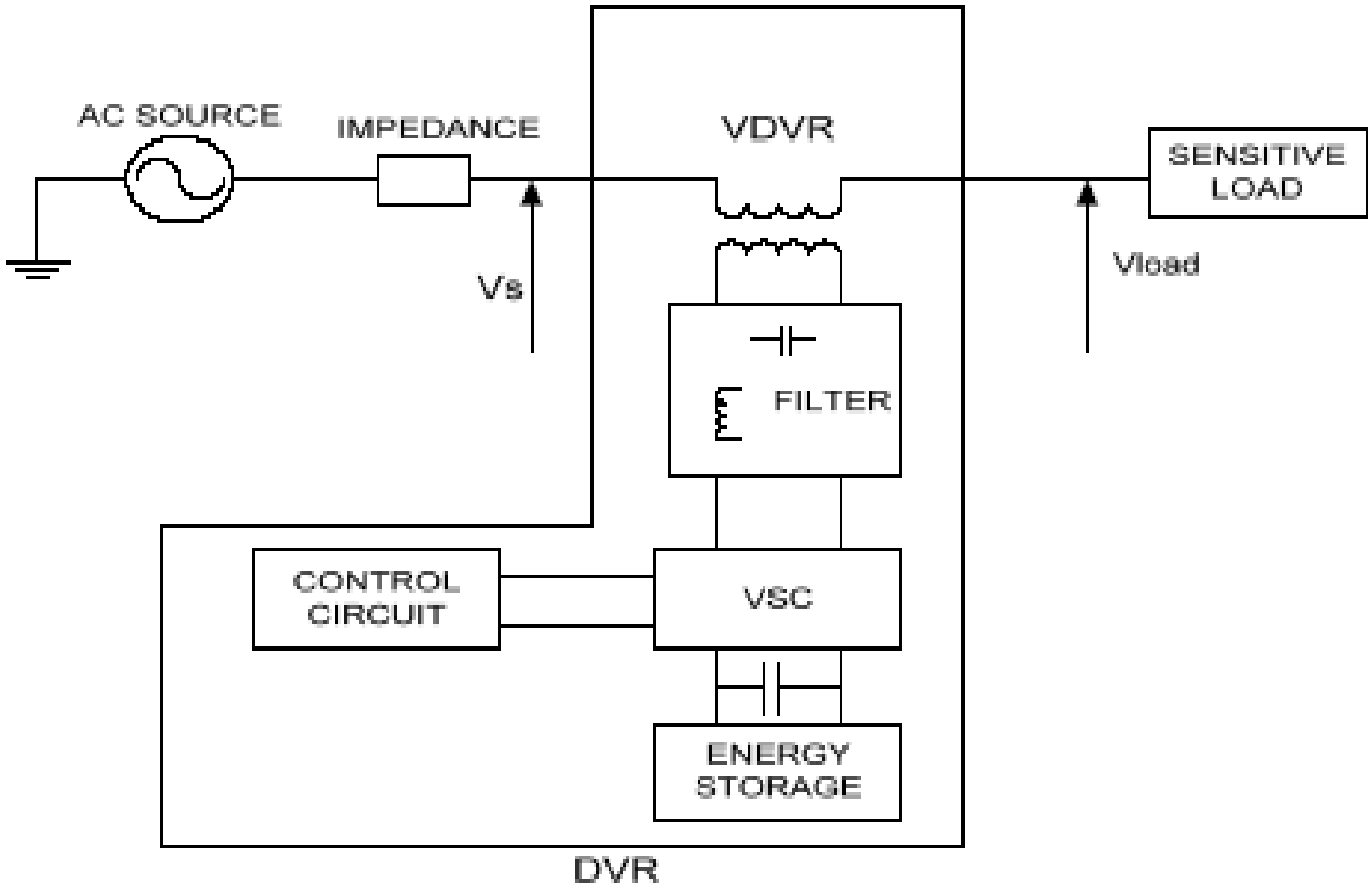
# Flow Chart for DVR Control Technique



# Main Elements in DVR

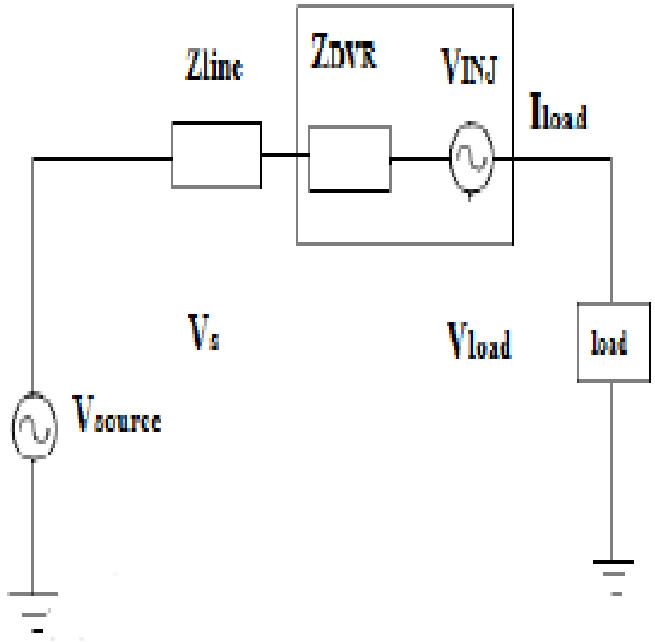
- An Injection / Series Transformer.
- Harmonic Filter.
- Voltage Source Converter (VSC).
- Energy Storage.
- Control Systems.

# DVR - Block Diagram

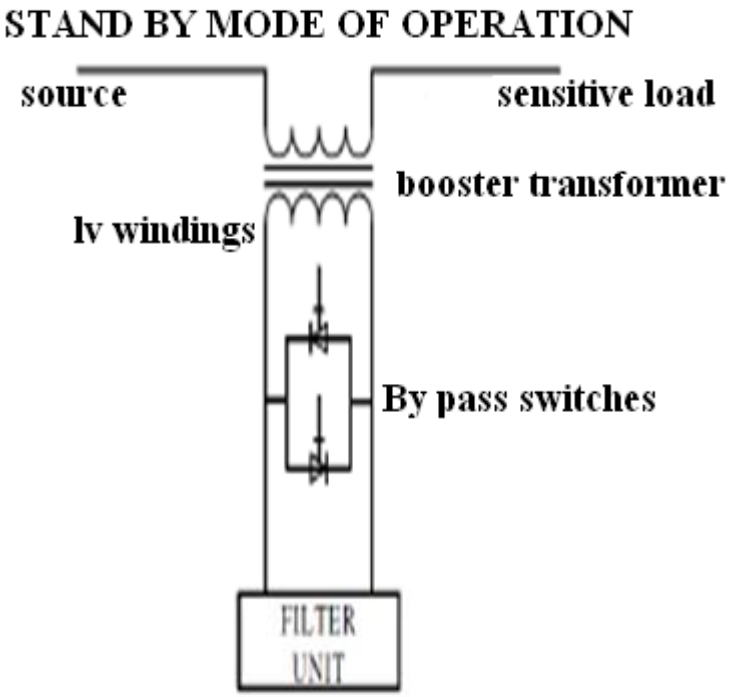


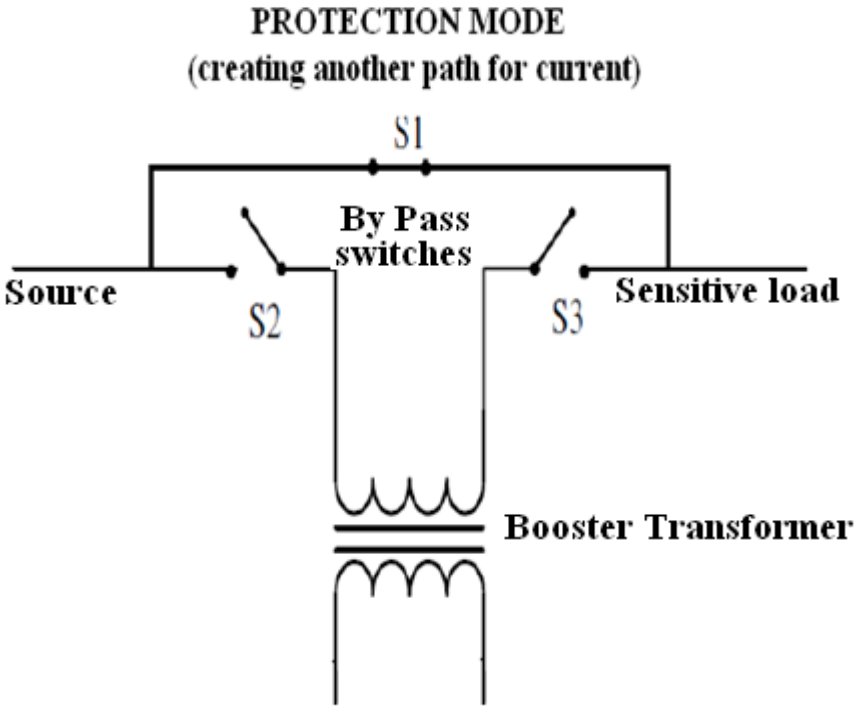
# DVR Equivalent Circuit Diagram

- $V_{DVR} = V_L + Z_{TH} I_L - V_{TH}$
- $V_L$ =The Desired Load Voltage Magnitude.
- $Z_{TH}$ =The load impedance.
- $I_L$ = The load current.
- $v_{TH}$ = The system voltage during load condition.



# DVR Modes of Operation



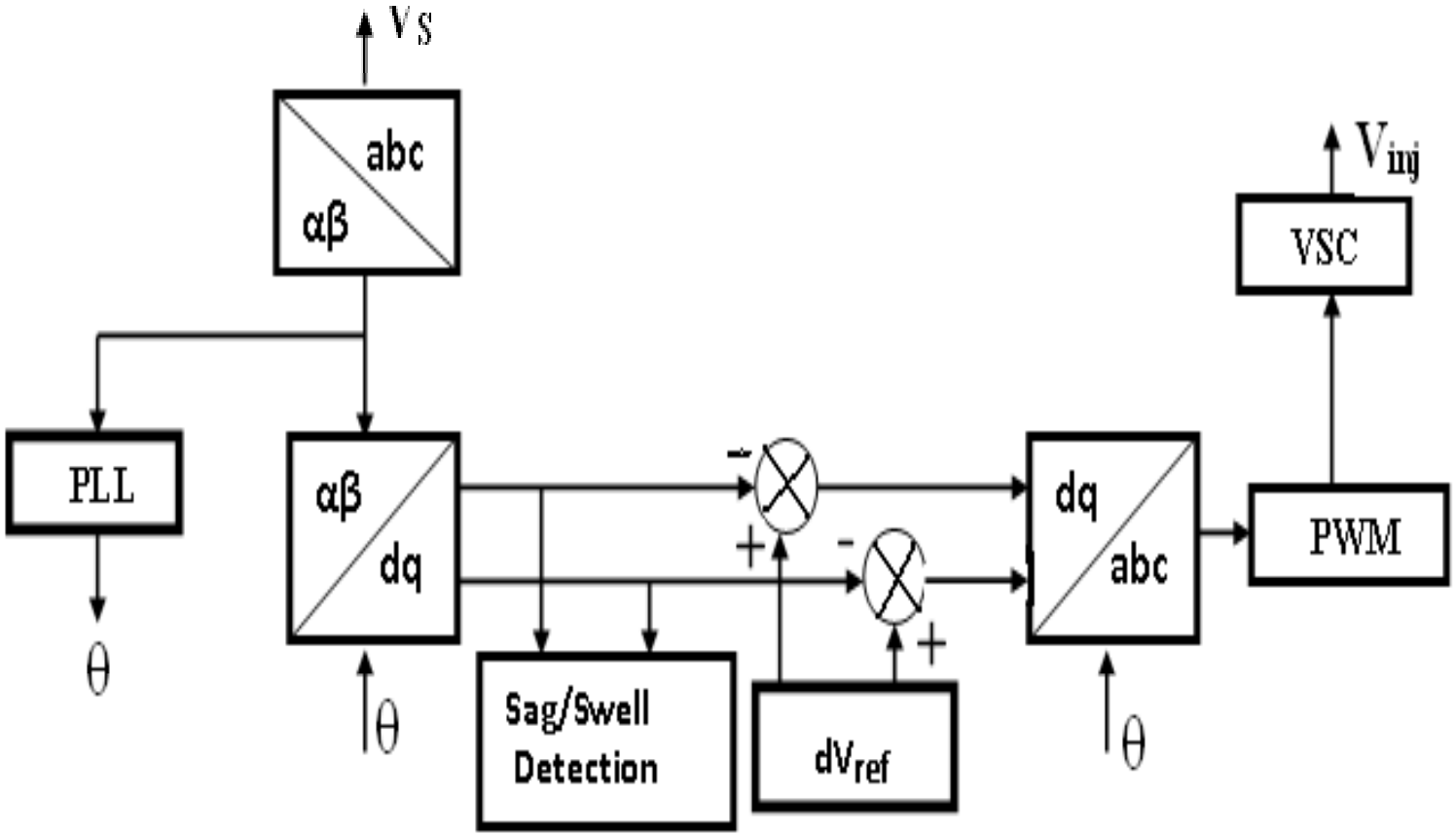



# DVR Modes of Operation...

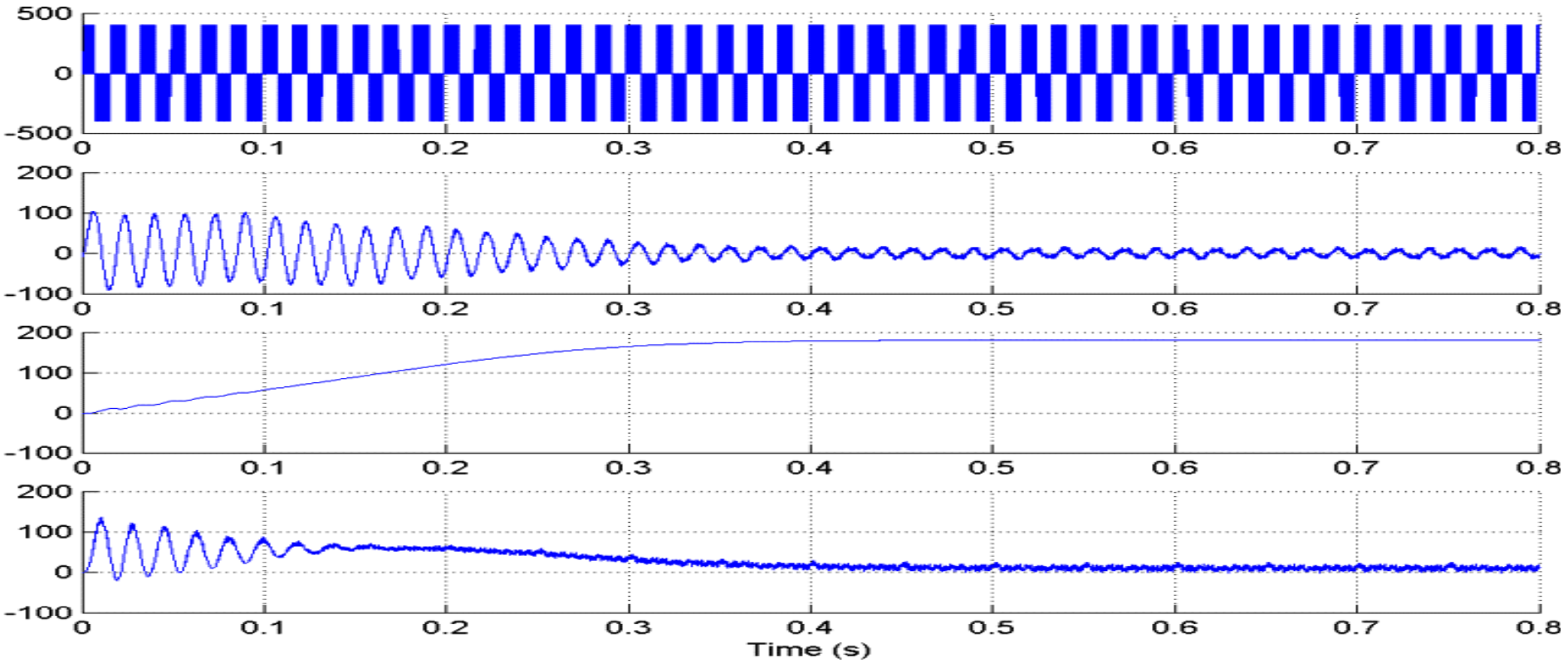
- In **Standby Mode** (***$V_{DVR}=0$***),the booster transformer's low voltage winding is shorted through the converter.

- In **Boost Mode (*Or*) Injection Mode** (***$V_{DVR}>0$***), the DVR is injecting a compensation voltage through the booster transformer due to a detection of a supply voltage disturbances.

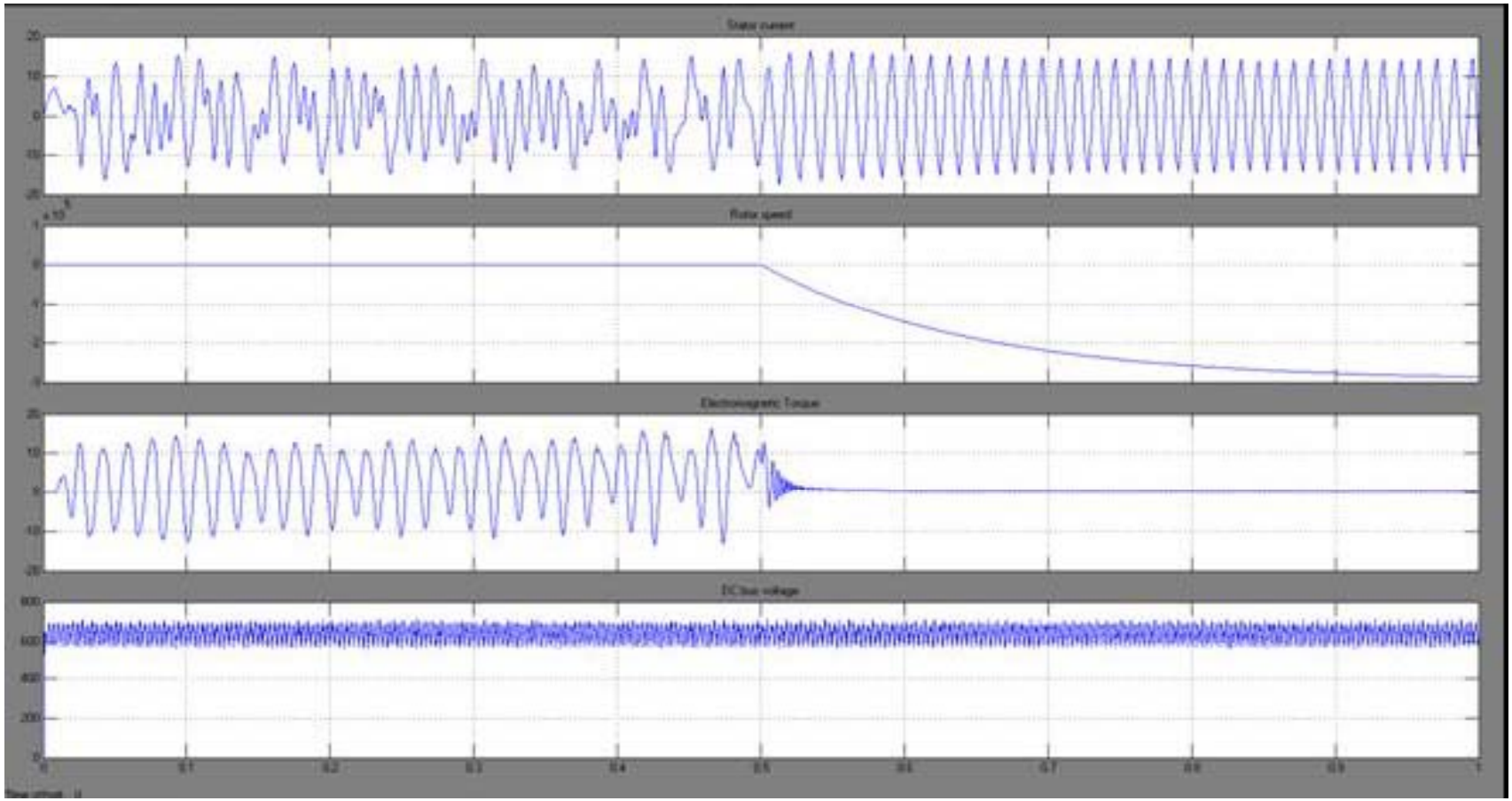
# DVR Control Systems



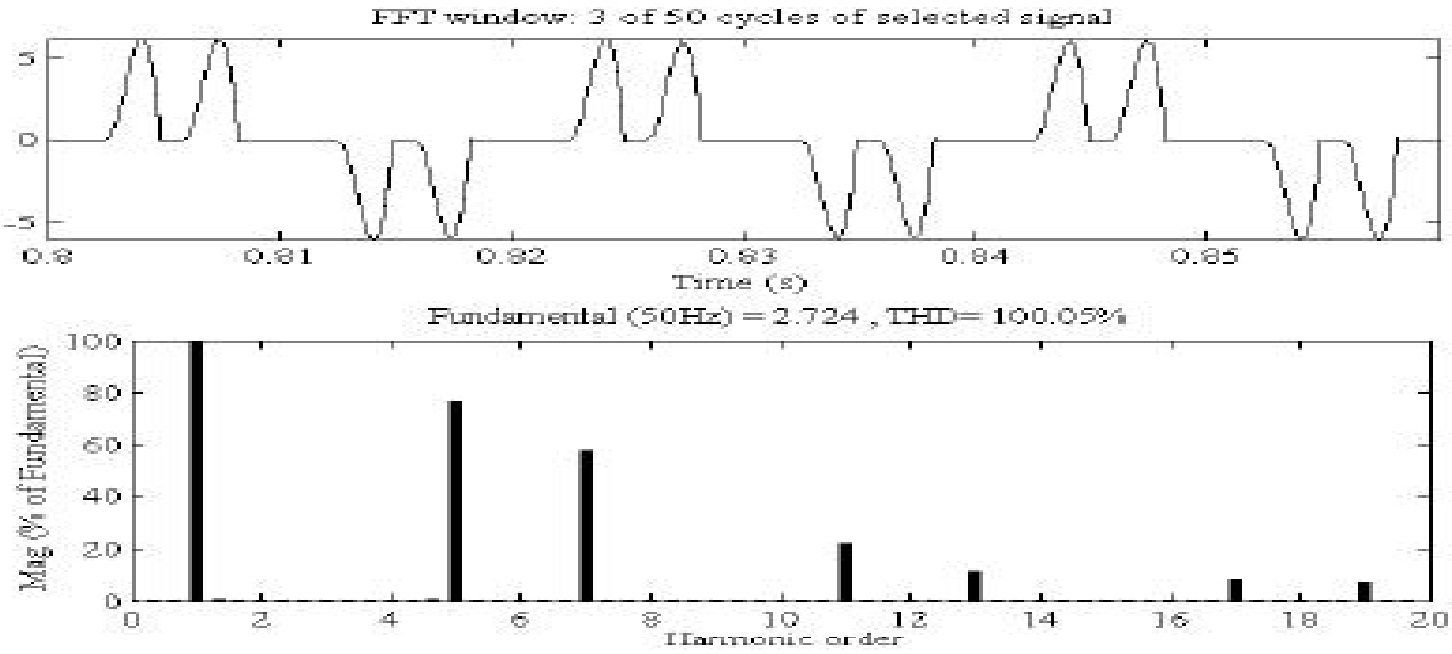
# DTC based IMD phase voltage (*Vas*), line current (*Ias*), rotor speed (*Nr*), electromagnetic torque (Te).



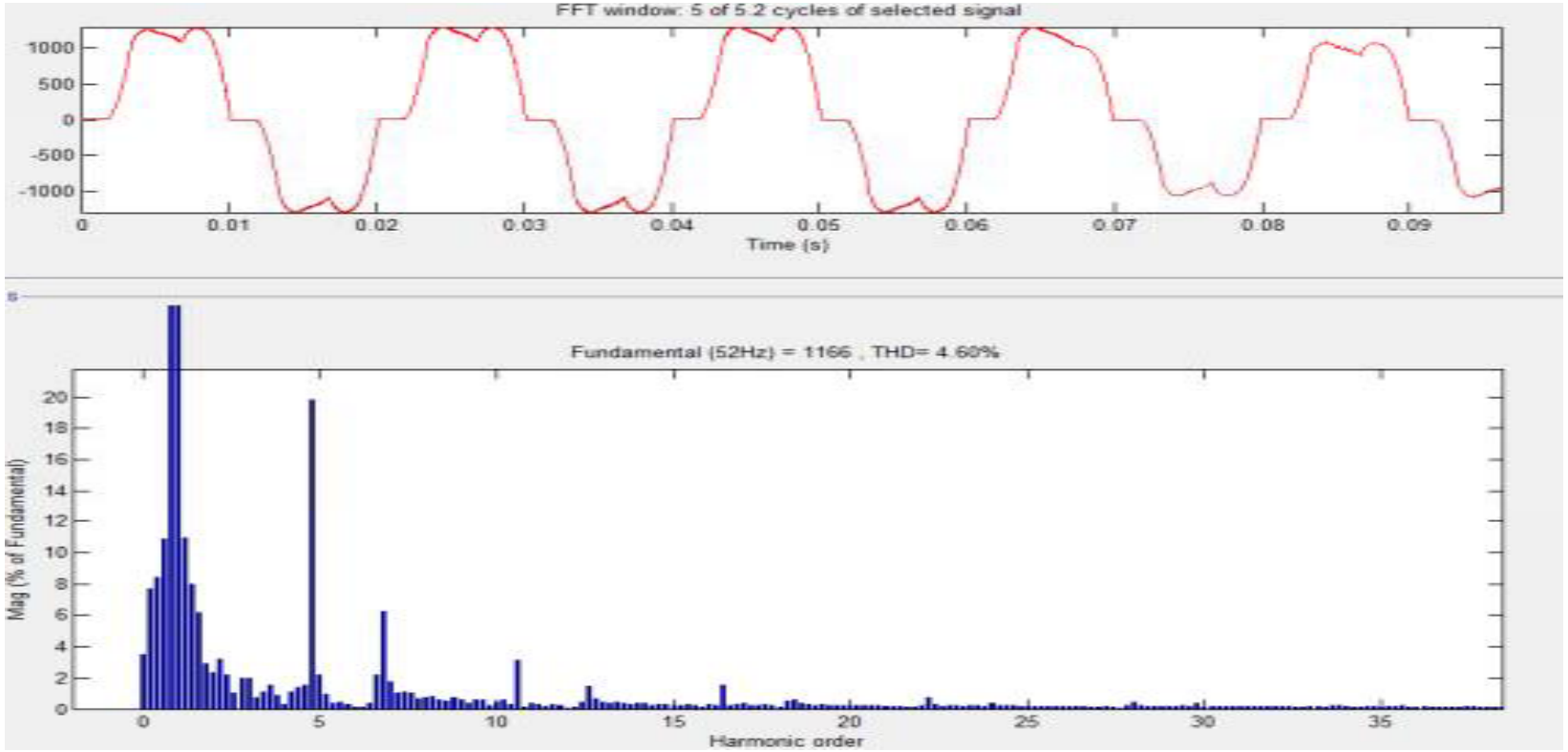
# Source current and harmonic spectrum for DTC based IMD with a simple diode bridge rectifier at rated load.



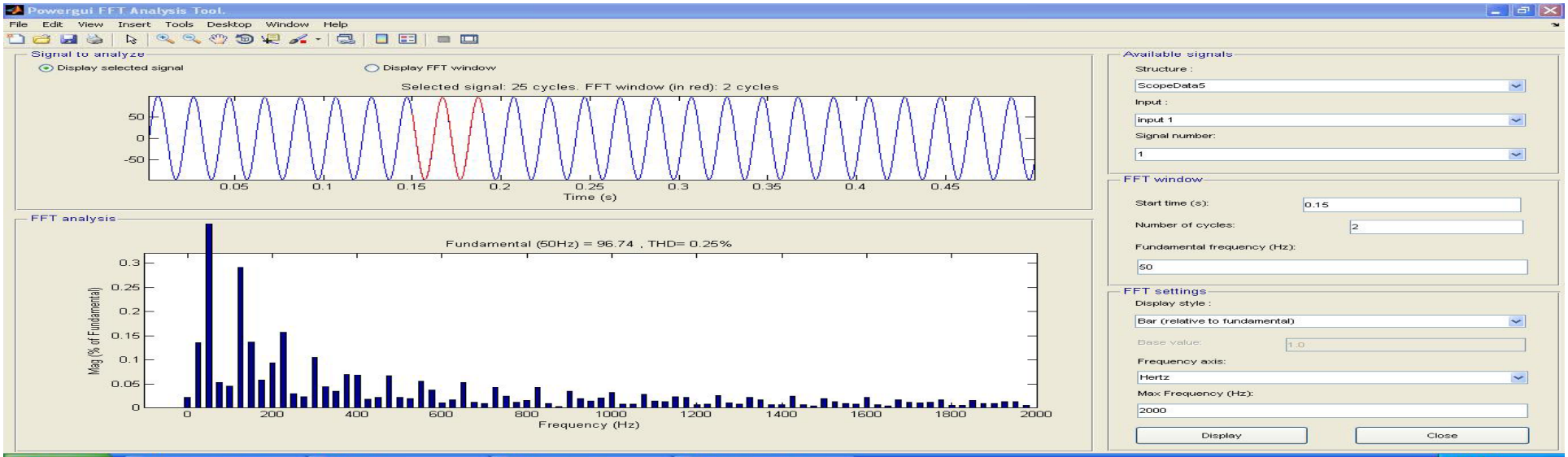
# Dynamics of a DTC based IMD with a simple diode bridge rectifier and Multi-Level DVR at the front end.

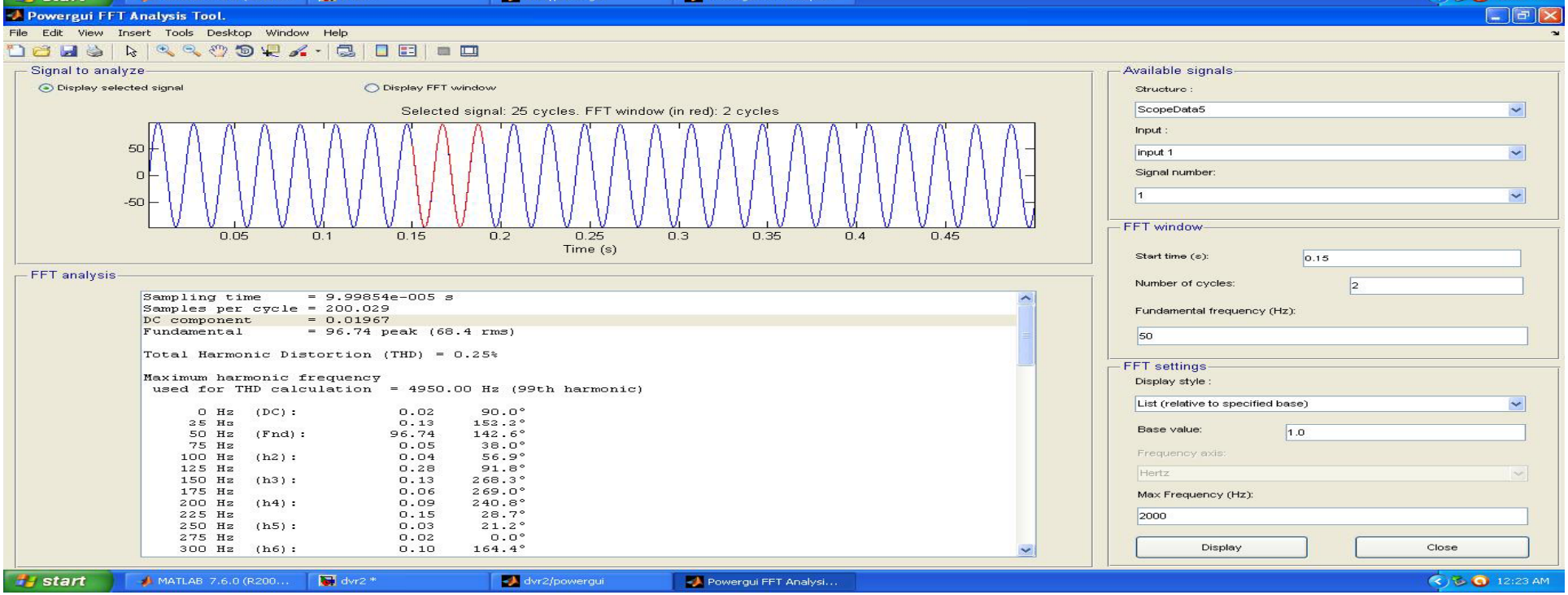


# AC mains current and harmonic spectrum for DTC based IMD with Multi Level DVR at the front of DTC.

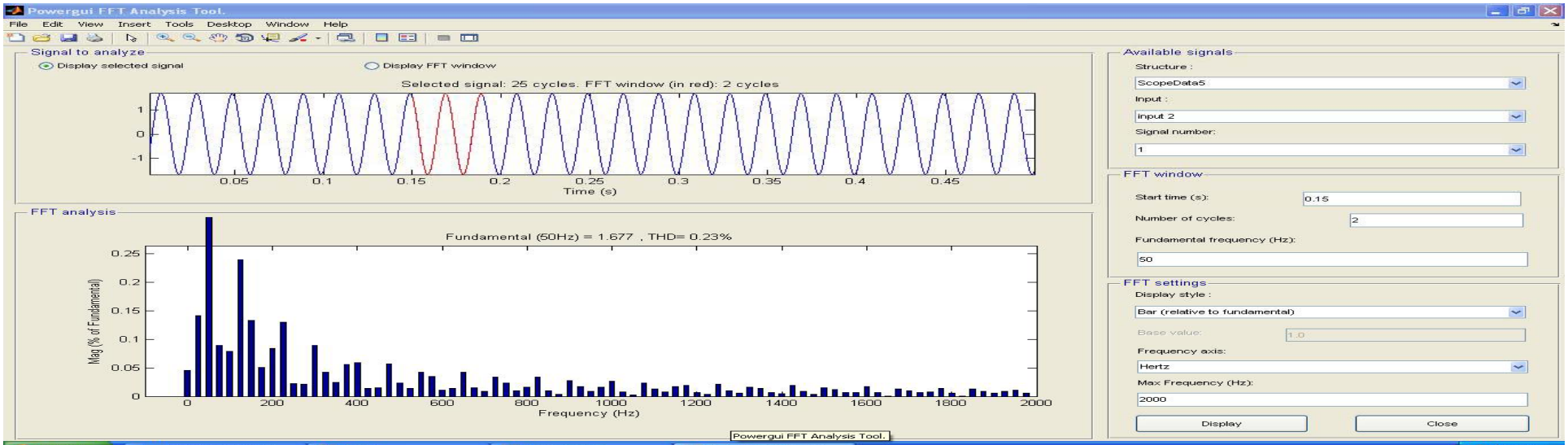


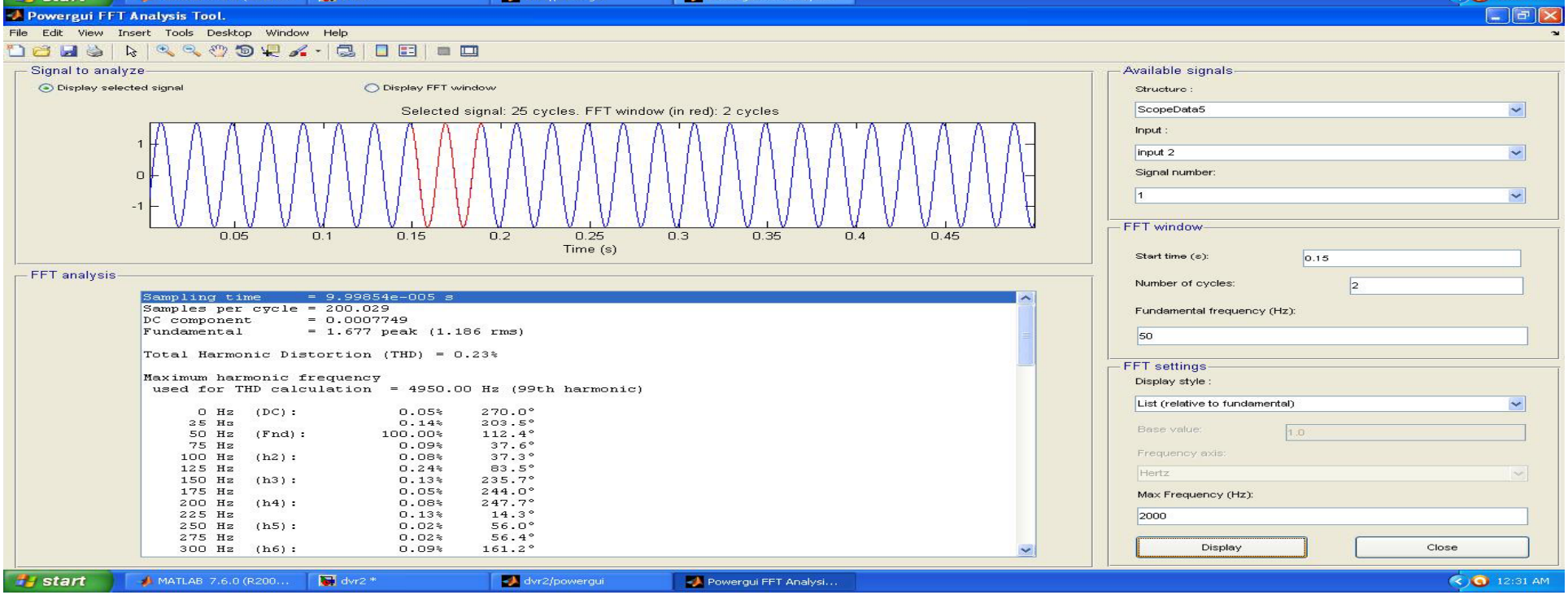
# Harmonics in ‘LOAD VOLTAGE’



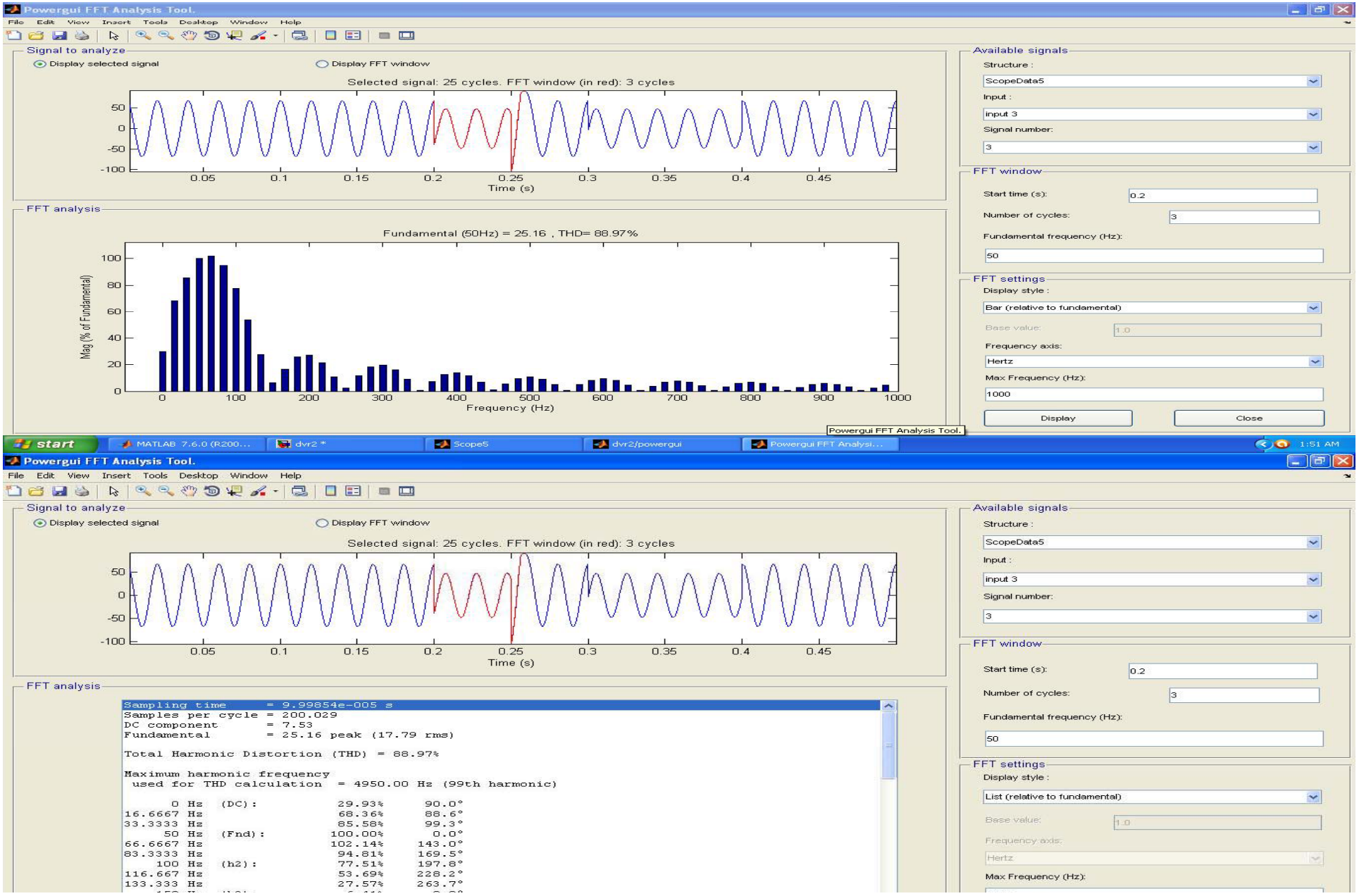



# Harmonics in ‘LOAD CURRENT’

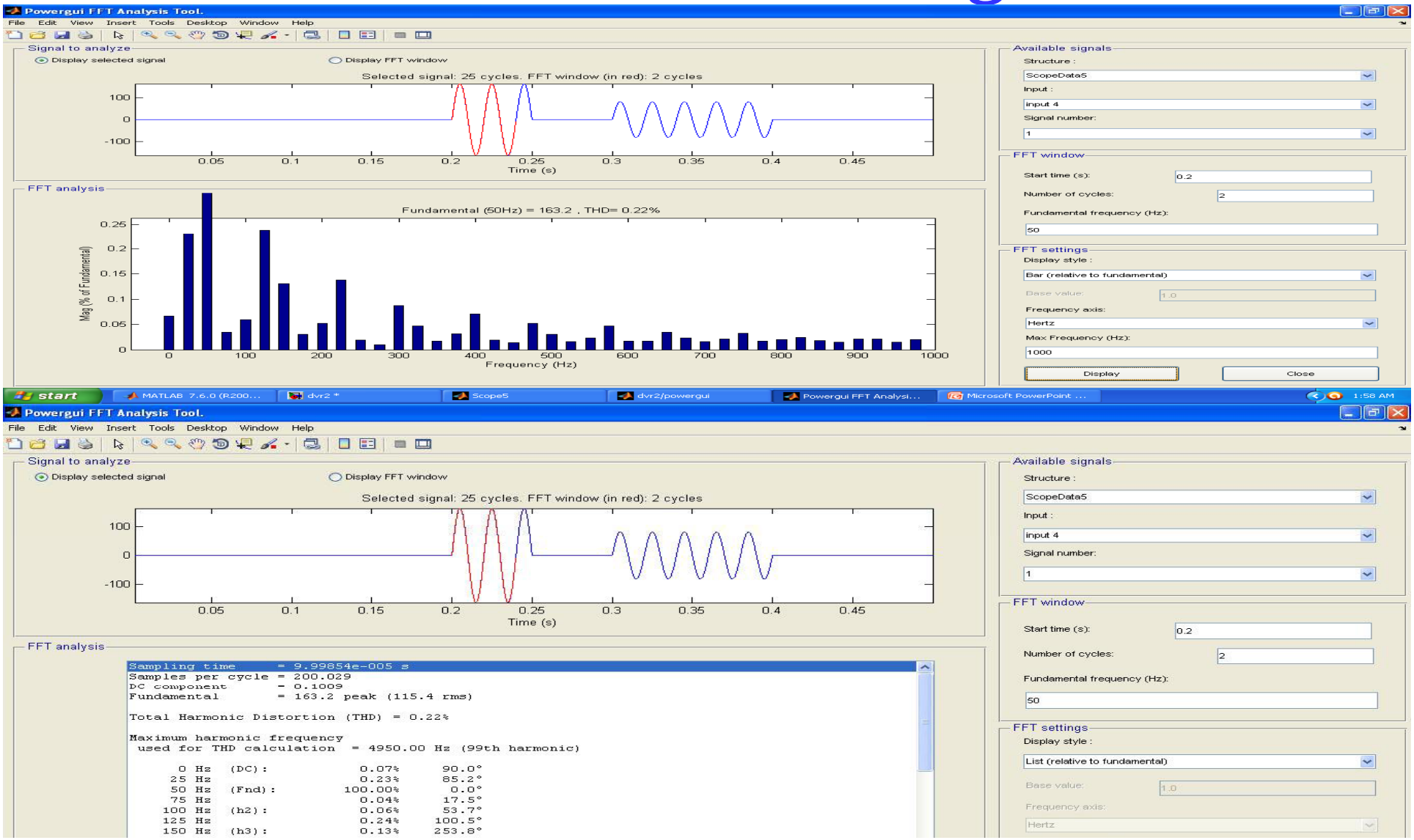


# Harmonics in S/M During 'SLG' Fault



# DVR Injects Voltage During ‘SLG’ Fault &Harmonics Range



# Reference


1. Ebrahim Babaei, Mohammad Farhadi Kangarul, "**Mitigation of Voltage Disturbances Using Dynamic Voltage Restorer Based on Direct Converters**" *IEEE Trans. Power Del.,* vol. 25, no.4,Oct2010.
2. P. R. Sánchez, E. Acha, J. E. O. Calderon, V. Feliu, and A. G. Cerrada, **"A Versatile Control Scheme for a Dynamic Voltage Restorer for Power-Quality Improvement,"** *IEEE Trans. Power Del.*, vol. 24, no. 1, pp. 277–284, Jan. 2009.
3. B.Wang and G.Venkataramanan, **"Dynamic Voltage Restorer Utilizing a Matrix Converter and Flywheel Energy Storage,"** *IEEE Trans. Ind. Appl.*, vol. 45, no. 1, pp. 222–231, Jan./Feb. 2009.
4. T. Jimichi, H. Fujita, and H. Akagi, **"Design And Experimentation Of A dynamic Voltage Restorer Capable Of Significantly Reducing An Energy storage element,"** *IEEE Trans. Ind. Appl.*, vol. 44, no. 3, pp. 817–825, May/Jun. 2008.
5. C. S. Lam, M. C. Wong, and Y. D. Han, **"Voltage Swell and Overvoltage Compensation with Unidirectional Power Flow Controlled Dynamic Voltage Restorer,"** *IEEE Trans. Power Del.*, vol. 23, no. 4, pp.2513–2521, Oct. 2008.
6. Raj Naidoo, Pragasen Pillay, **"A New Method of Voltage Sag and Swell Detection"** *IEEE Trans. Power Del.,* vol. 22, no.2,Apr.2007.

# Reference…


7. Mostafa I. Marei, Ehab F. El-Saadany, Magdy M. A. Salama, **"A New Approach to Control DVR Based onSymmetrical Components Estimation"** *IEEE Trans. Power Del,* vol. 22, no. 4, oct.2007
8. B.Wang, G. Venkataramanan, and M. Illindala, **"Operation and Control of a Dynamic Voltage Restorer Using Transformer Coupled H-Bridge Converters,"** *IEEE Trans. Power Electron.*, vol. 21, no. 4, pp. 1053–1061, Jul. 2006.
9. A.Elnady and M. M. A. Salama, **"Mitigation Of Voltage Disturbances using Adaptive Perceptron-Based Control Algorithm,"** *IEEE Trans. Power Del.*, vol. 20, no. 1, pp. 309–318, Jan. 2005.
10. P. Chiang, D. M. Vilathgamuwa, S. K. Tang, and H. L. Long, **"Multilevel Dynamic Voltage Restorer,"** *IEEE Power Electron. Lett.*, vol. 2, no. 4, pp. 125–130, Dec. 2004.
11. C. Zhan, A. Arulampalam, and N. Jenkins, **"Four-Wire Dynamic Voltage Restorer Based on a Three Dimensional Voltage Space Vector PWM Algorithm,"** *IEEE Trans. Power Electron.*, vol. 18, no. 4, pp. 1093–1102, Jul. 2003.
12. D. Soto and T. C. Green, **"A Comparison of High-Power Converter Topologies for the Implementation of Facts Controllers,"** *IEEE Trans. Ind. Electron.*, vol. 49, no. 5, pp. 1072–1080, Oct. 2002.

# Thank you...