A Novel Hybrid Smart Grid-PV-FC V2G Battery Charging Scheme

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Contents

Abstract

- This paper presents a Novel Hybrid Smart Grid- PV-FC V2G Battery Charging Scheme using FACTS based low impact battery charging scheme for Electric Vehicles.
- The FACTS is fully stabilized using a hybrid Green Power Filter Compensator (GPFC), that ensures a fully stabilized Common-DC
- Green pure Filter Compensation Scheme for V2G Battery Charging Stations with a novel multi regulators multi loop error driven control strategy to ensure fast charging.
- The Battery Charging FACTS Based V2G Station is controlled by a Dual-loop error driven regulators to ensure near unity power factor operation, reduced harmonic distortion and decoupled AC-DC Grid Operation. The battery charger has a hybrid Voltage-Current Regulation.

Introduction

- Electric vehicle is one of the solutions for decreasing the fossil fuel consumption and pollutant emissions of gas, responsible for the green house effect. However, pure battery electric vehicles have shown their own range limitations, because of their size the vehicle habitability is compact so as its range. Adding different kinds of power supply in the same vehicle like Photovoltaic and Fuel Cell allow taking advantages from their different characteristics
- There are some barriers related to high penetration of plug- in vehicles and electric vehicles EV. Nevertheless, widely believed, that plug-in vehicles and EVs will become common within some time frame, but there are differences of opinion about when and at what rate the market penetration will happen.

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- Batteries are appropriate for transportation appliances and they are very expensive at the moment, but the technology is continuously evolving and prices are expected to go down. Secondly, a lack of adequate charging infrastructure is a major barrier. Constructing wide charging infrastructure would be probably fairly expensive especially in densely populated areas.

- The proposed system consists of six parts. There are DC voltage supplies like a Photovoltaic PV and Fuel Cell. In the same time, there three phase supply, Green Plug Power Filter Compensator GPFC, DC/DC chopper, and DC load. In this study, Photovoltaic PV, Fuel Cell and three phase supply are giving the required voltage and current ratings to charge Lithium-ion Battery.

System Description

The hybrid renewable energy scheme utilizes quasi-steady state and equivalent volt-ampere circuit models, of the FC battery and PV array and Lithium-ION Battery. These parity- based models are quite sufficient in validating proposed control strategies for DC bus stabilization, maximum energy utilization and dynamic FACTS-switched filter compensator scheme validation.

The proposed Hybrid Smart Grid-PV-FC V2G Battery Charging Scheme has the following parts:

1. *GPFC Filter Compensator*.
2. *Fuel Cell Energy System Model.*
3. *Photovoltaic Energy System Model.*
4. *Lithium-ion Battery Energy System Model.*

A Novel Hybrid Smart Grid-PV-FC V2G Battery Charging Scheme

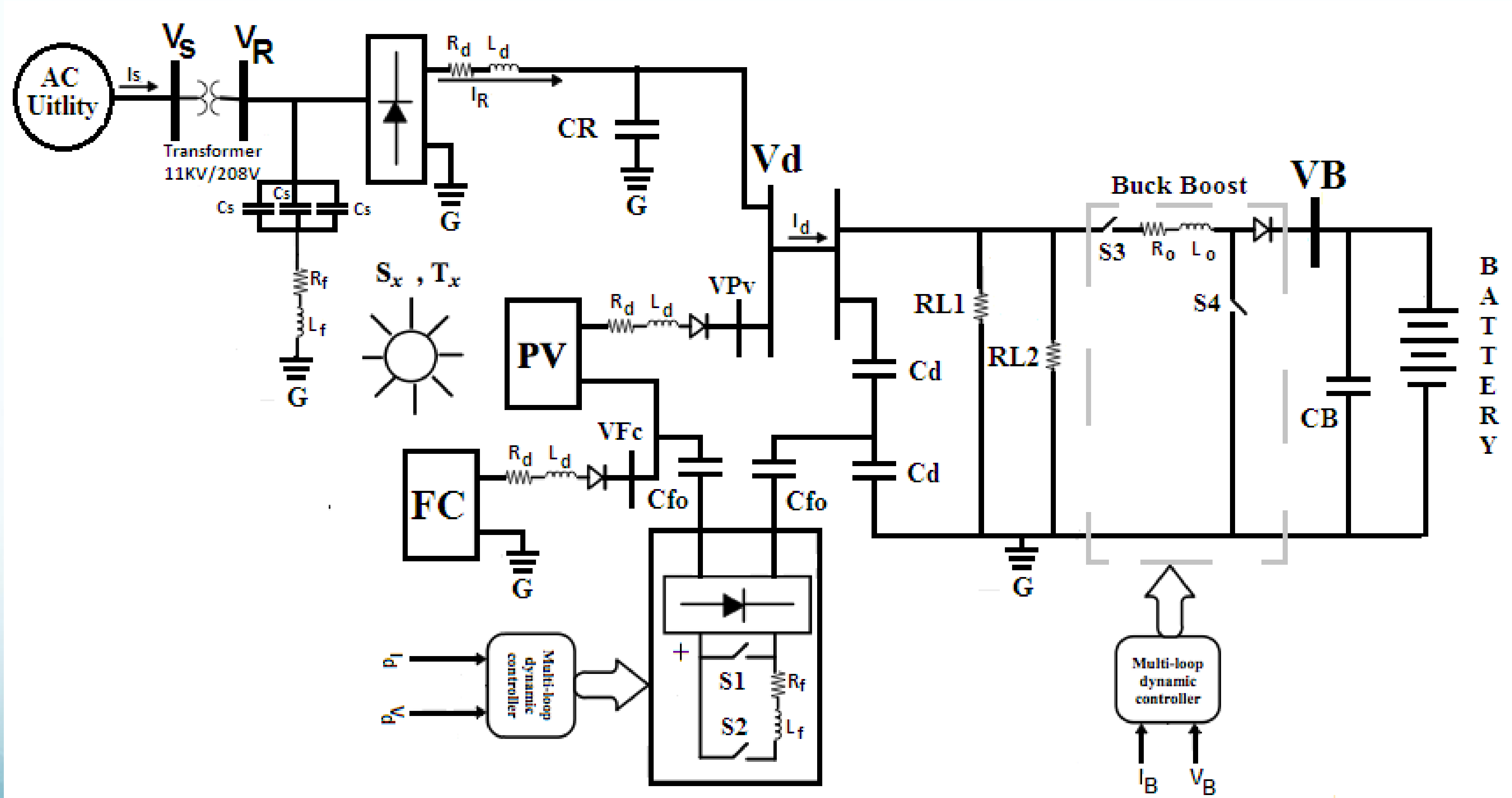


Fig.1

Green Plug Power Filter GPFC

- In order to enhance the Hybrid Smart Grid-PV-FC V2G Battery Charging Scheme performance a green plug capacitor filter GPFC comprising switchable capacitor is introduced at the DC bus.
- The GPPF is also controlled to absorb ripple and reduce DC side current oscillations.
- The idea behind the controller is to detect major excursions in the motor measurements and feed the errors to a PWM module that in turn generates the switching pulses to the filter switches in accordance with the duty ratio and the error value.
- The GPPF used and tested with the operation system is shown in Fig.1, Fig.2.

Green Plug Power Filter (GPFC)-developed by Professor Dr. Sharaf

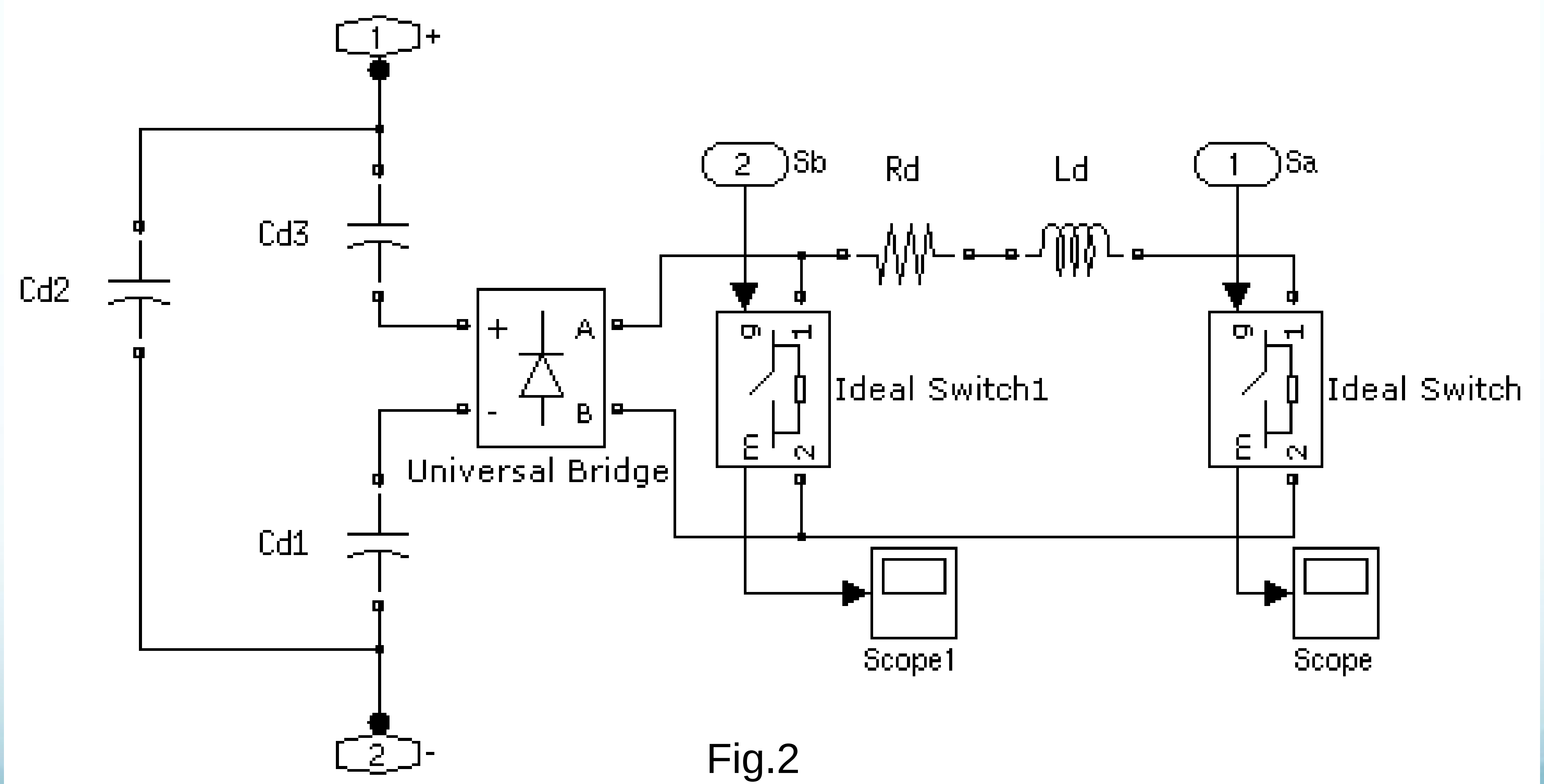


Fig.2

Dynamic Error Driven Control

- In this paper, the novel Modified Dual-loop error driven dynamic controller scheme shown in Fig. (3) was implemented to control and for GPFC Filter, which comprises two basic loops, namely the main voltage stabilization loop and the cur- rent dynamic error loop. The additional dynamic loops ensure energy efficient utilization and reduced current ripple content.
- The novel Modified Multi-loop error driven dynamic controller scheme shown in Figs. (4,5) were implemented for GPFC controlled to control absorb ripple and reduce DC side current oscillations, which comprises two basic loops, namely the main voltage stabilization loop, and current dynamic error loop.

Cont..

- The novel Modified Dual-loop error driven dynamic controller was implemented to control both GPFC and Buck Boost Chopper. The total error signal (et) is the sum of these three basic dynamically scaled loop errors that presents by:

$$e_t = (\gamma_S \cdot e_S + \gamma_I \cdot e_I + \gamma_R \cdot e_R)$$

$$V_c(t) = \gamma_1 e_t(t) + \gamma_2 \int_0^t e_t(t)dt + \gamma_3 \int_0^t (e_t(t))^2 dt$$

Multi loop The Weighted Modified PID (WMPID).

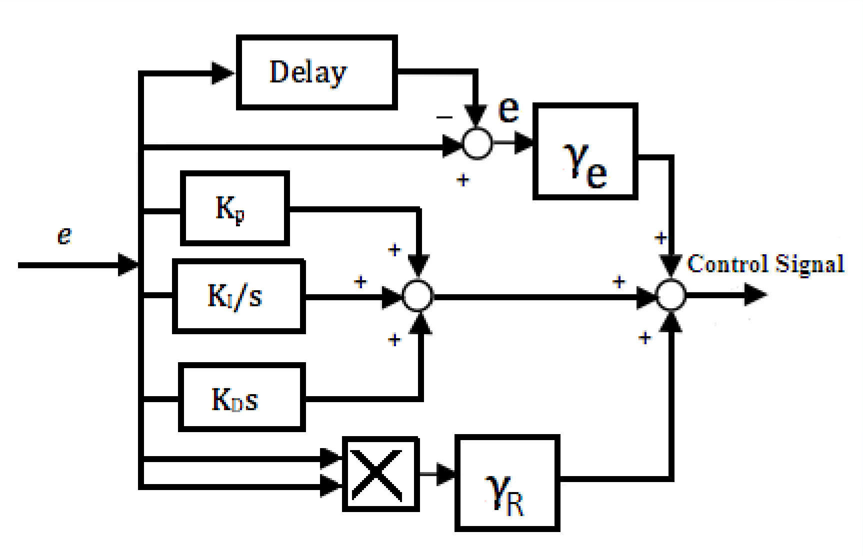
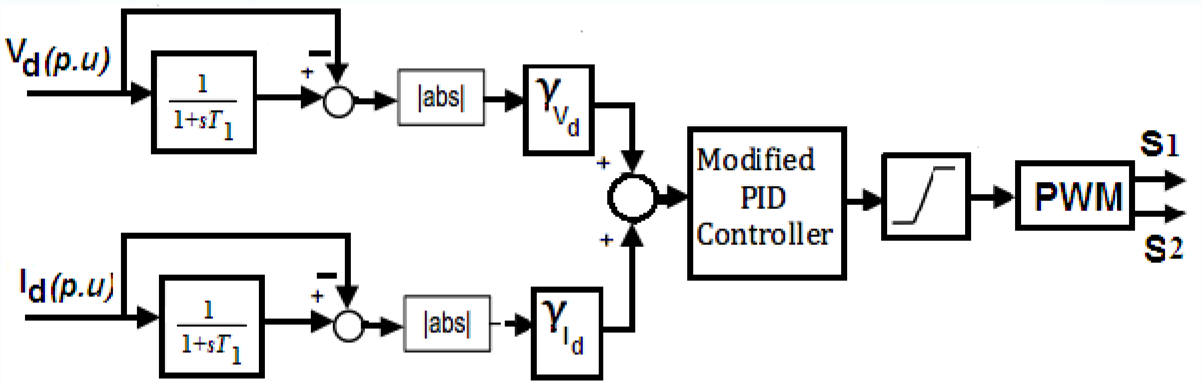
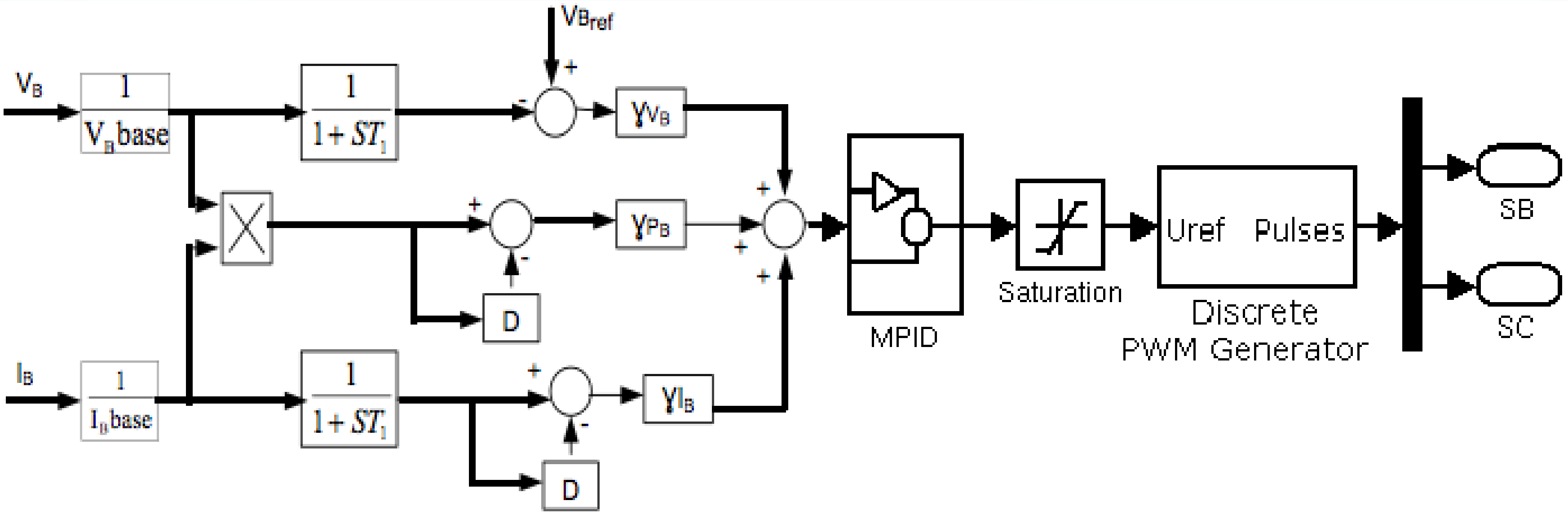


Fig.3

Cont….



Vd(p.u)
Id(p.u)
1
1+sT1
|abs|
Modified
PID
Controller
PWM
S1
S2



VB
IB
VBref
1
VBbase
1
IBbase
1
1+ST1
D
MPID
Saturation
Uref
Pulses
Discrete
PWM Generator
SB
SC

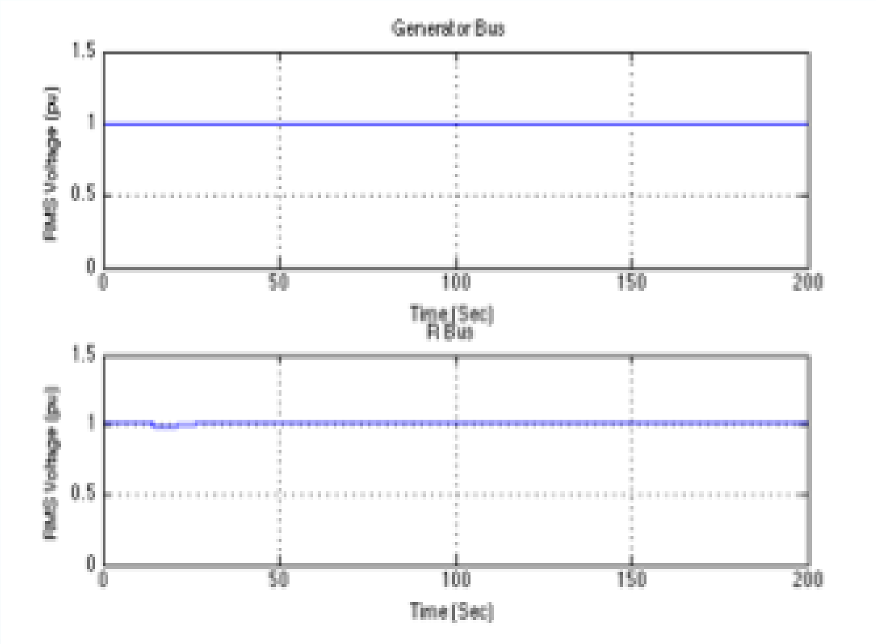
Fig.4.

Digital Simulation Results Using MATLAB

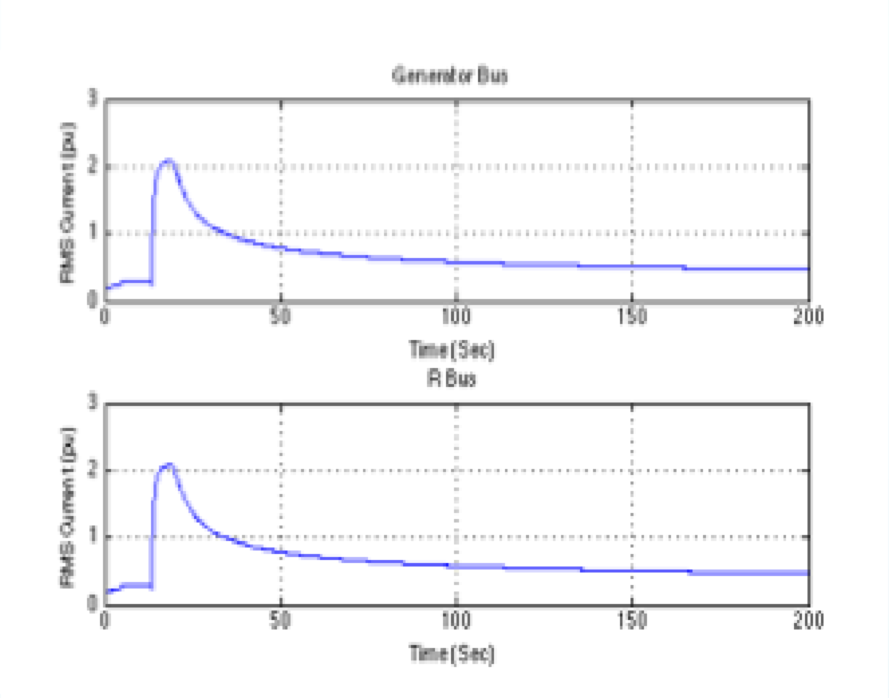
Three digital simulation case studies have been studied, including typical excursions, disturbances and faults:

- ✓ *Normal Case (*In this case, there was no disturbances on the system).
- ✓ *AC Bus Open Circuit Fault.*
- ✓ *AC Bus Short Circuit Fault.*

Digital Simulation Results

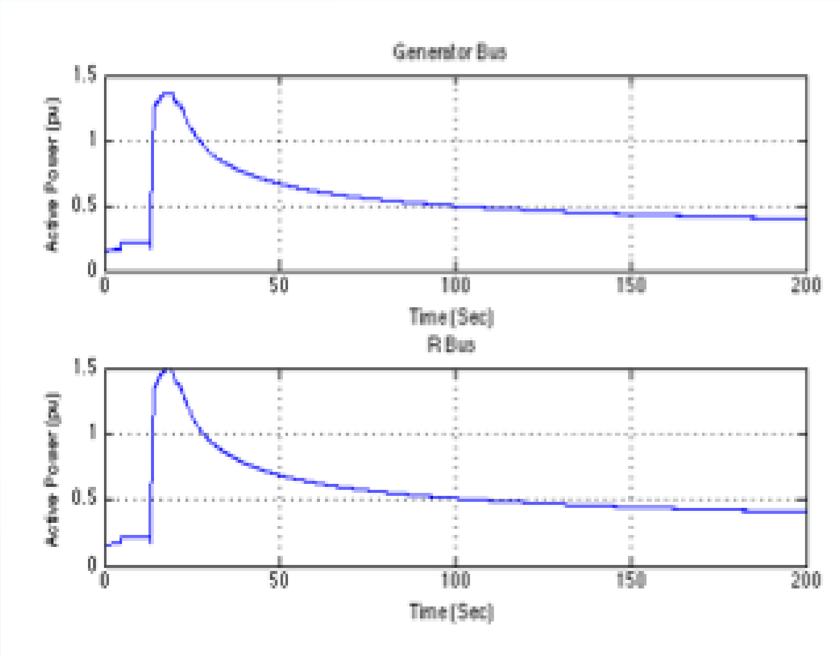


Dynamic response for RMS Voltage at
Generation Bus and R Bus.

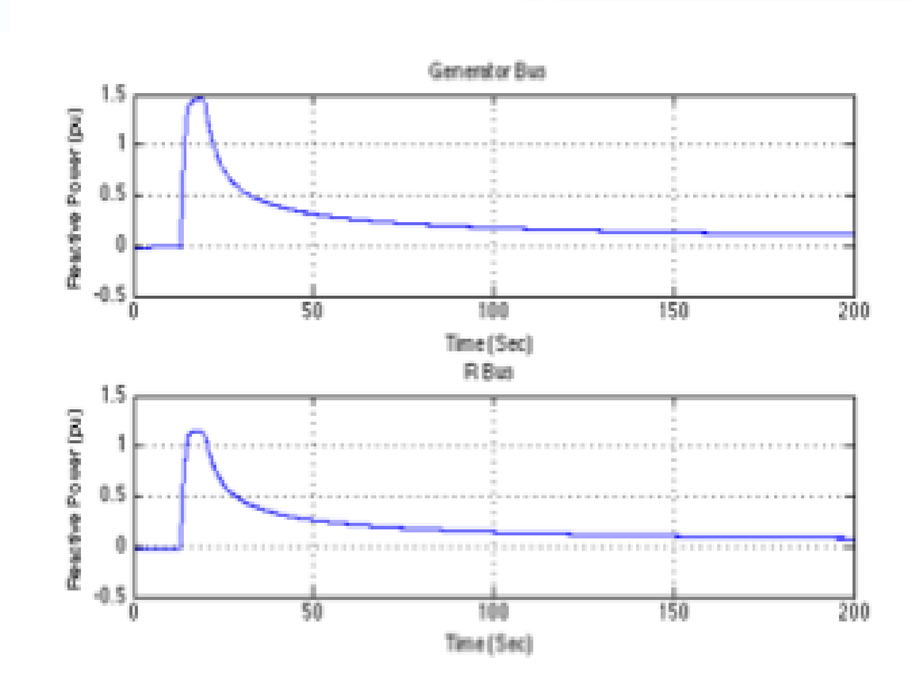


Dynamic response for RMS Current at
Generation Bus and R Bus.

Digital Simulation Results

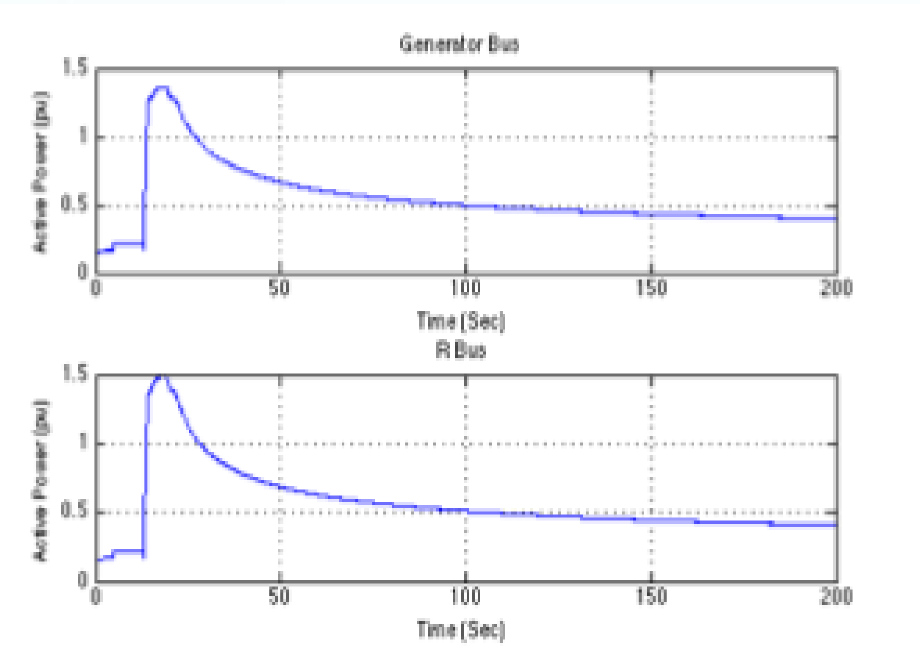


Dynamic response for RMS Active Power at Generation Bus and R Bus

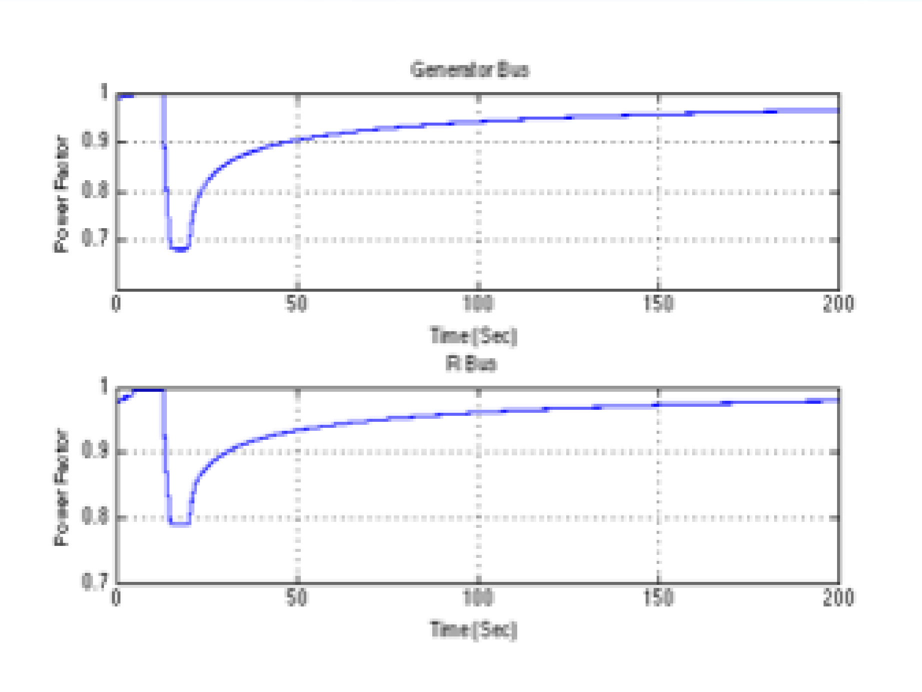


Dynamic response for RMS Reactive Power at Generation Bus and R Bus

Digital Simulation Results

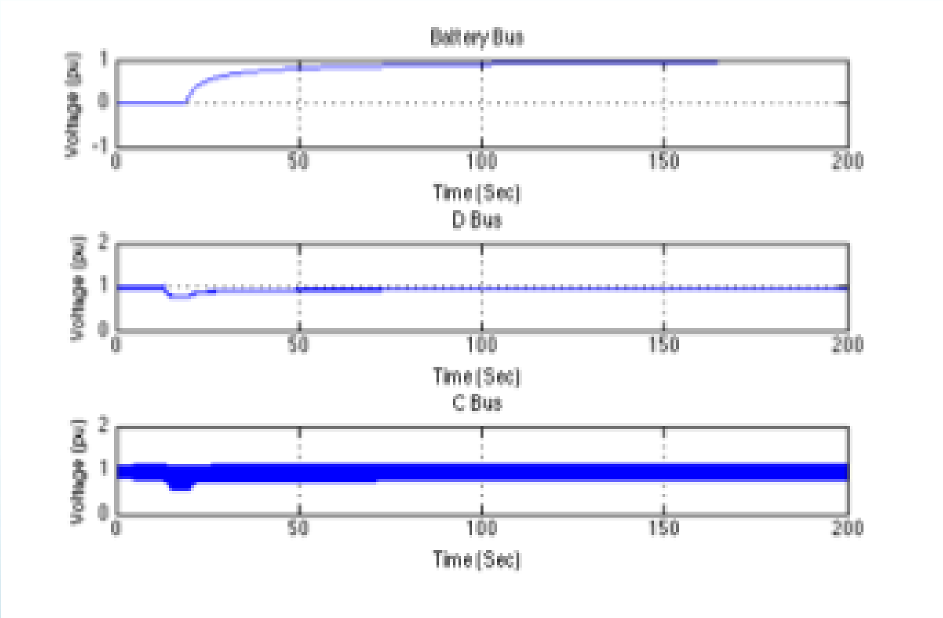


Dynamic response for RMS Apparent Power at Generation Bus and R Bus

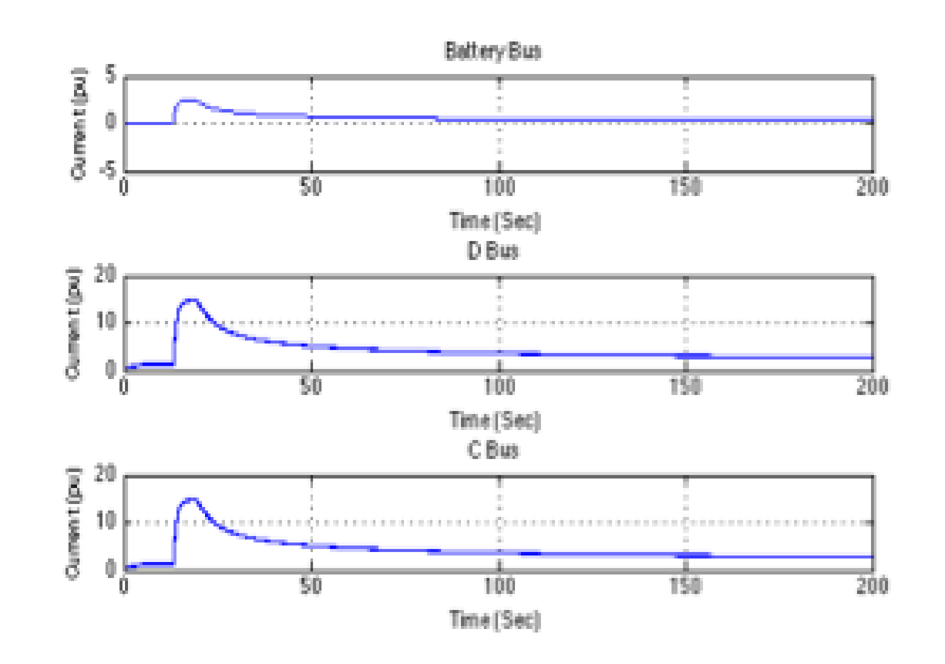


Power Factor at Generation Bus and R Bus.

Digital Simulation Results

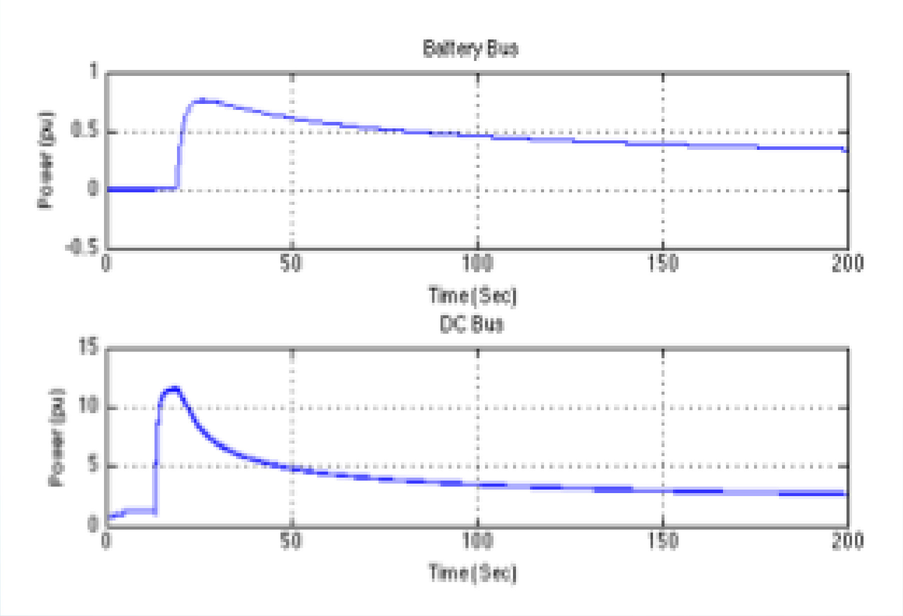


Dynamic response for the Voltage at
Battery Bus, D Bus and C Bus

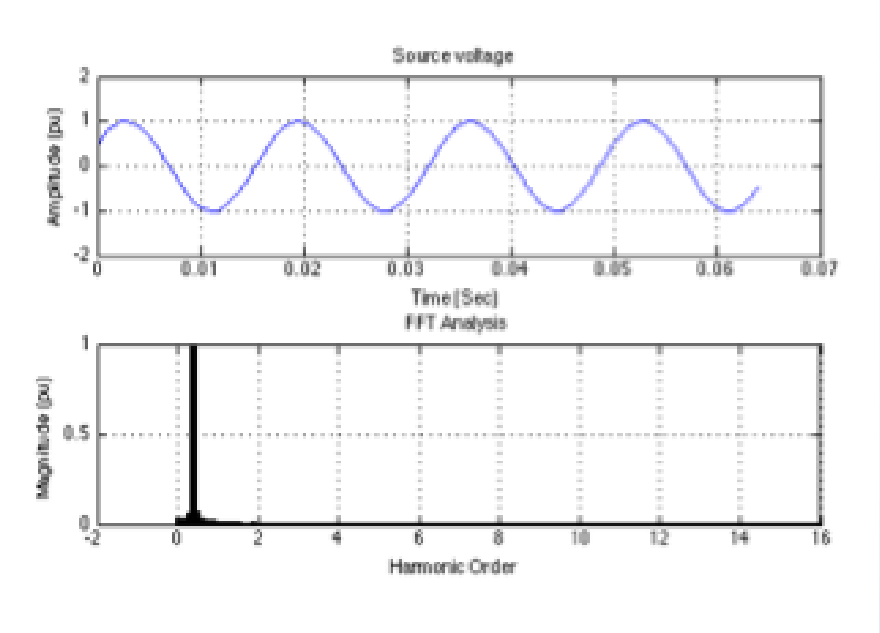


Dynamic response for the Curent at
Battery Bus, D Bus and C Bus

Digital Simulation Results

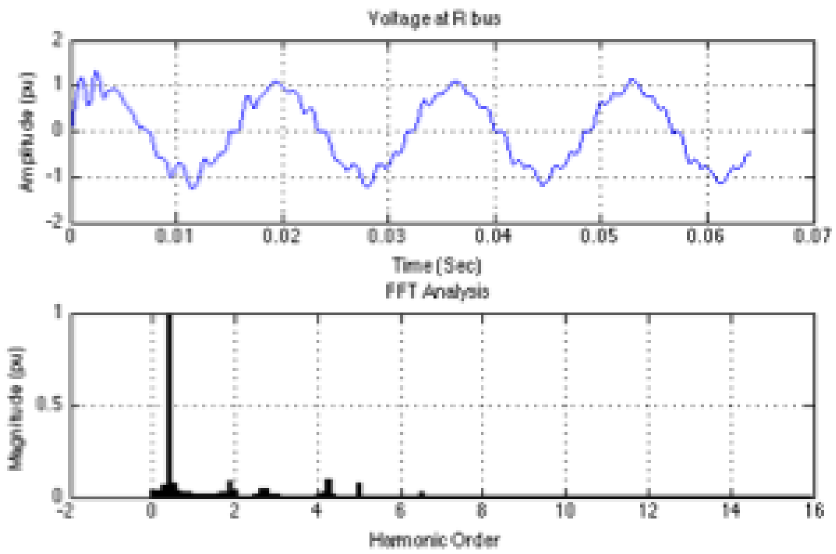


Dynamic response for the Power at Battery Bus, D Bus and C Bus.

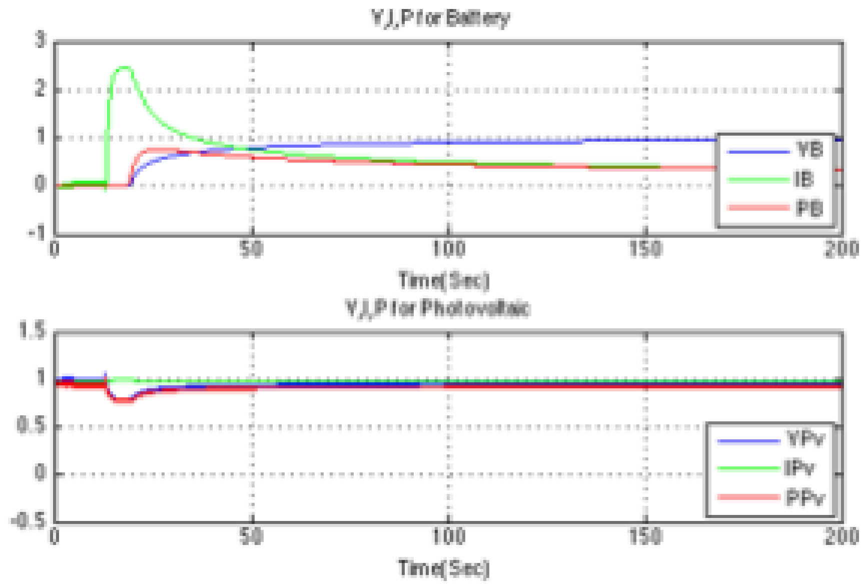


FFT Analysis for Voltage signal at Generation Bus.

Digital Simulation Results

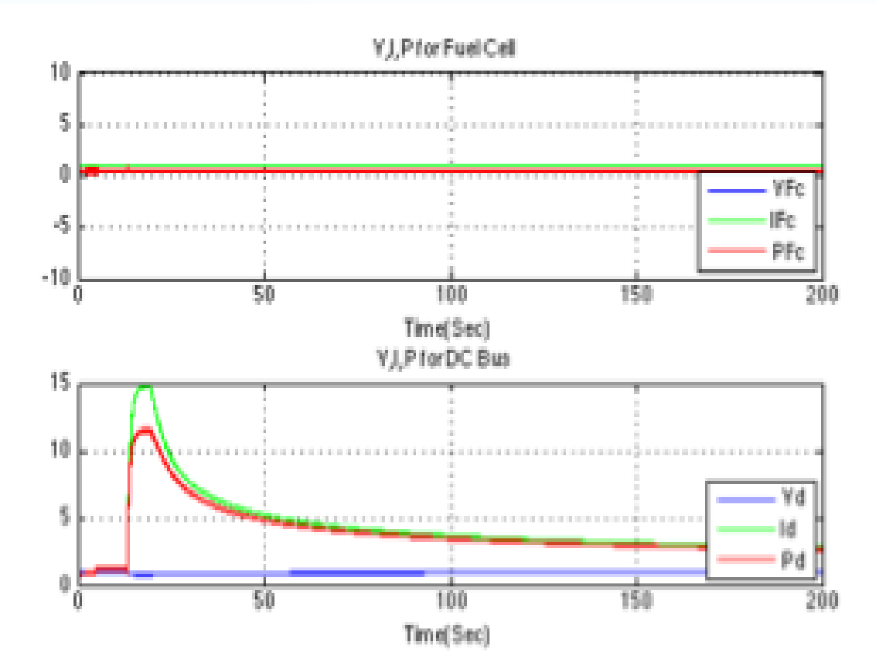


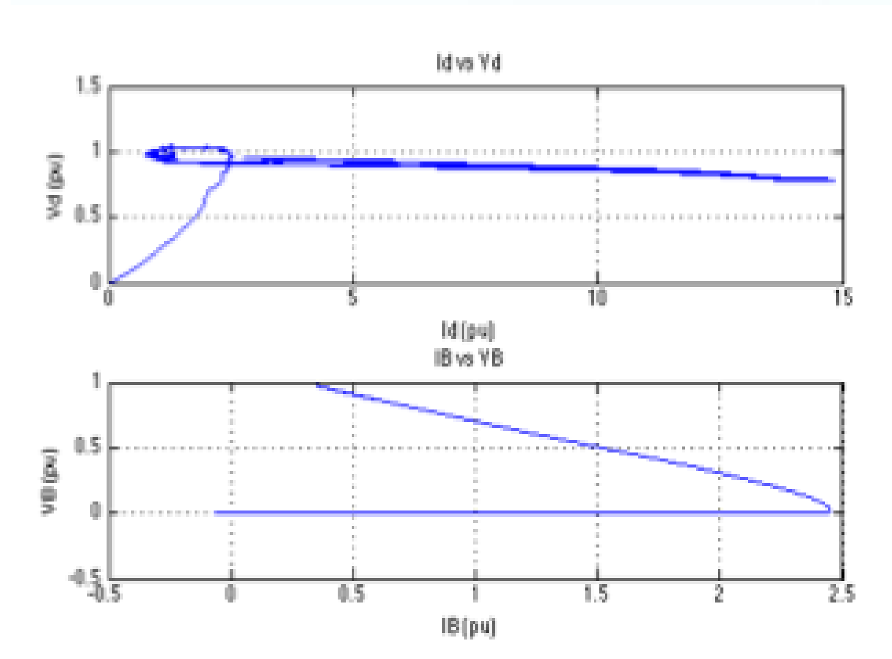
FFT Analysis for Voltage signal at R Bus.



Dynamic response for Voltage, Current and Power signals at Battery & Photovoltaic Buses.

Digital Simulation Results

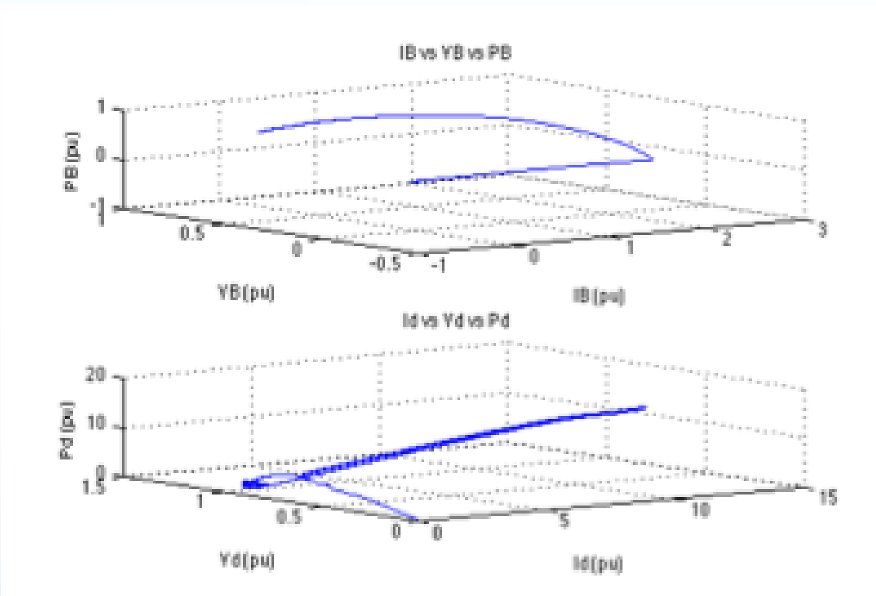




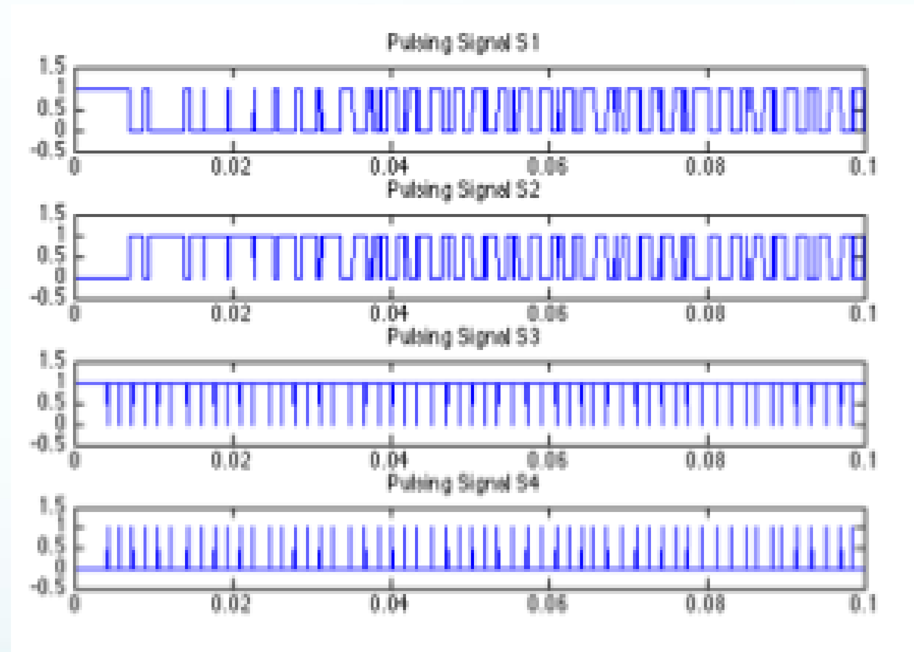
Dynamic response for Voltage, Current and Power signals at Fuel Cell & DC Buses.

Dynamic response for Voltage vs Current at Battery Bus and DC Bus.

Digital Simulation Results

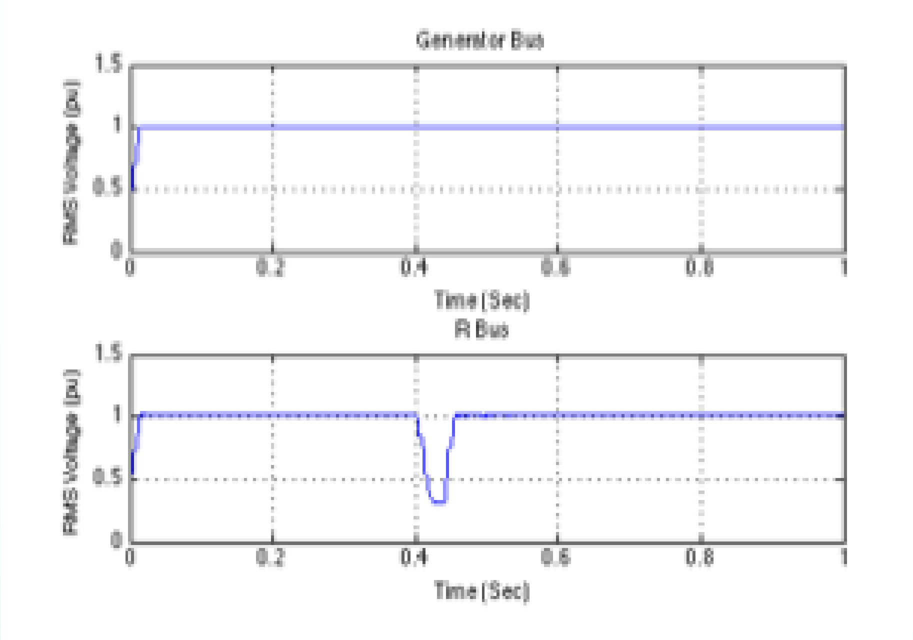


Dynamic response for Voltage, Current and Power signals at Battery Bus and D Bus.

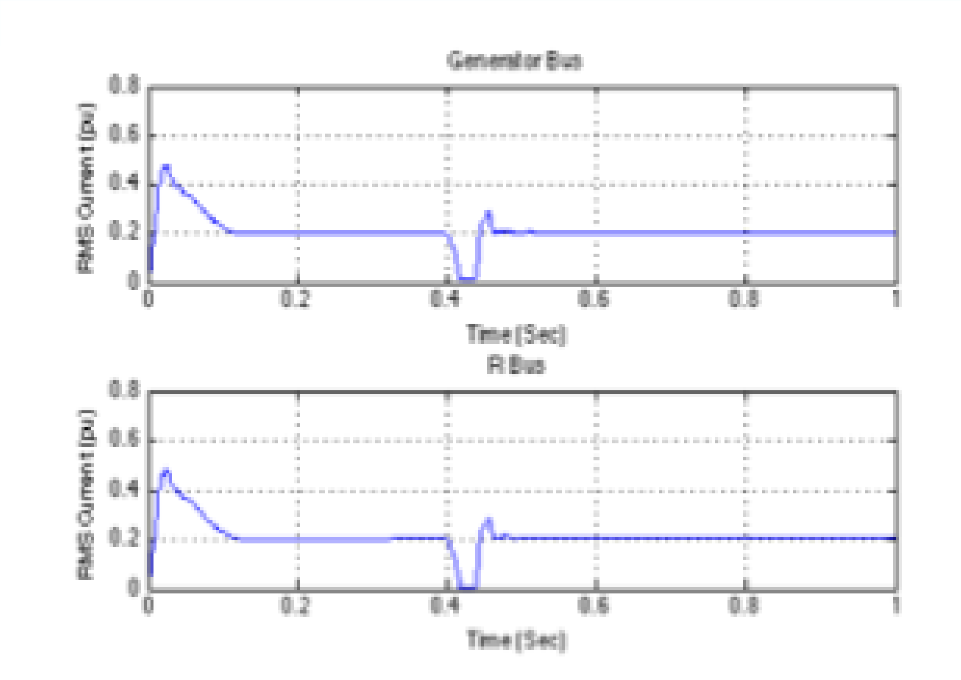


The switching pulses (S1, S1, S3 and S4).

Digital Simulation Results



Dynamic response for RMS Voltage at Generation Bus and R Bus during OC fault.



Dynamic response for RMS Current at Generation Bus and R Bus during OC fault.

Conclusion

- This paper presents a novel FACTS Green Power Filter Compensation (GPFC) Scheme for V2G Battery Charging Stations with a novel multi regulator multi loop error driven control strategy to ensure fast charging, minimal impact on host electric grid and efficient utilization of grid-connected battery charging scheme with effective AC-DC decoupling and stabilization of the DC Common Bus Voltage. The self regulating battery charging multi-regulator control scheme is fully validated using the random search optimization and search algorithms. The battery charger is controlled by a Dual-loop error driven regulators to ensure near unity power factor operation, reduced harmonic distortion and decoupled AC-DC Grid Operation.
- The battery charger has a hybrid Voltage- Current Regulation. The proposed DC Common Bus interface Scheme utilized a switched Green Plug Filter Compensation Scheme to stabilize the DC bus voltage and ensure efficient utilization. The novel DACTS based AC-DC Devices and co- ordinated Control Strategy using error driven multi-regulation scheme ensures common AC and DC stabilization, decoupled AC-DC operation and efficient Energy Utilization. The V2G scheme illustrates the use of Renewable Energy in Micro- Grid Commercial Battery Charging Stations. The flexible multi- regime charging Model provide flexibility and customization using Voltage and Current loop Weightings , especially for Fast-Charging Mode.

Thank you