CAPSTONE PROJECT

Second-Review

Power converter topologies for bidirectional power flow in Vehicle to Grid (V2G) and Grid to Vehicle (G2V) Technologies (Tentative Title)

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Name:
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Problem statement:

- In response to climate change, which is caused by the increasing pollution of the environment which leads to the deterioration of human health, so future electricity generation should aim to reduce reliance on fossil fuels by growing the use of clean and renewable energy generation sources and also use clean vehicle technologies.

- The advantage of using battery system is that the cost can be decreased by lowering material costs, enhancing process efficiency and increasing production volume.

- Also by controlling bidirectional charging and discharging services of battery efficiently, it can further make it more suitable for renewable energy applications.

- A better solution where the battery system can be used to support the services, wherein the battery is still part of the source.

- Thus, aim is to use battery powered system to support the required services. Hence, the project is designing and control of converters for bi-direction flow of power in V2G (Vehicle to Grid) and G2V (Grid to Vehicle) configurations.

- This will support both the grid (in place) and traction (vehicle) with added auxiliary loads.

Objectives:

- The main objective of this project is to design and control of bidirectional converter (single phase and three phase), which is utilized for its easy implementation and almost constant common mode voltage.

- This allows a transformer-less system to simulate different topologies, for Low Voltage and High Voltage (output power range from 3.3 KW to 22 KW).

- The models of the converters and their controls will be designed and implemented in Matlab/Simulink.

- This will provide a detailed technical assessment, in conjunction with various power-electronics converter topologies, modeling and control strategies designed in terms of dynamic response and harmonics.

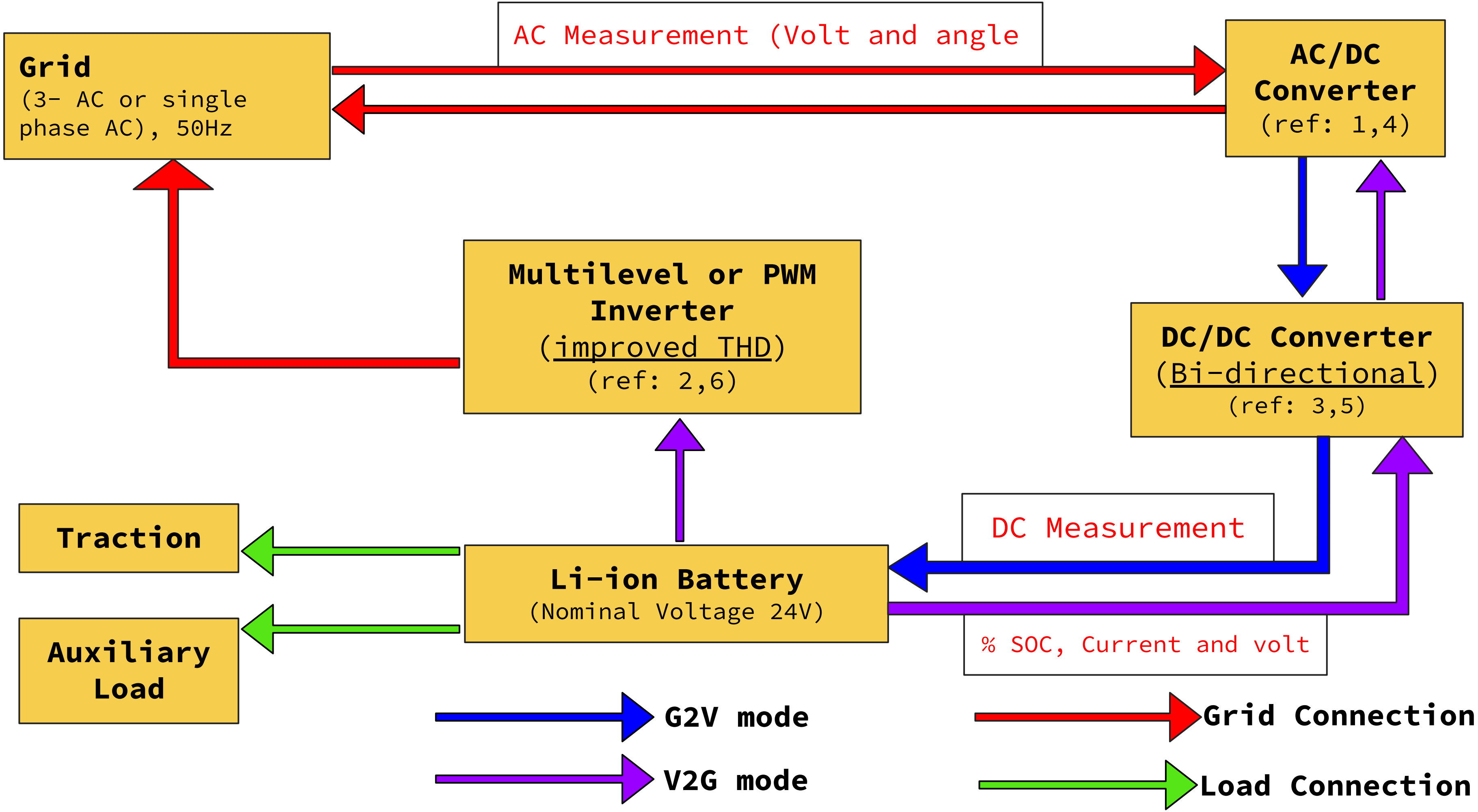
- This technology can provide numerous benefits to the electricity grid as long as a good control is implemented. It presents an efficient charging and discharging methodology to control the energy taken or given by the battery.

- Also, the grid current is used to establish faster grid current control loop and switching patterns for the converter, to control the energy given or taken from the grid.

Methodology:

MATLAB simulink would be used to design bi-directional power flow in V2G and G2V configurations, to achieve this following converter topologies will be implemented:

1. Three Phase Fully Controlled Full Wave Bridge Converter.
2. Three Phase PWM Inverter.
3. Model of DC-DC converter for Light Duty Vehicles (LDV : 3.3KW) i.e with single phase input .
4. Model of full bridge two-Quadrant converter for Heavy-Duty Vehicles (HDV : 22KW) i.e 3-phase input.
5. Model of full bridge two-Quadrant converter for implementing Reverse charging.
6. Simulink Model of G2V Multilevel/ Sin PWM inverter Topology

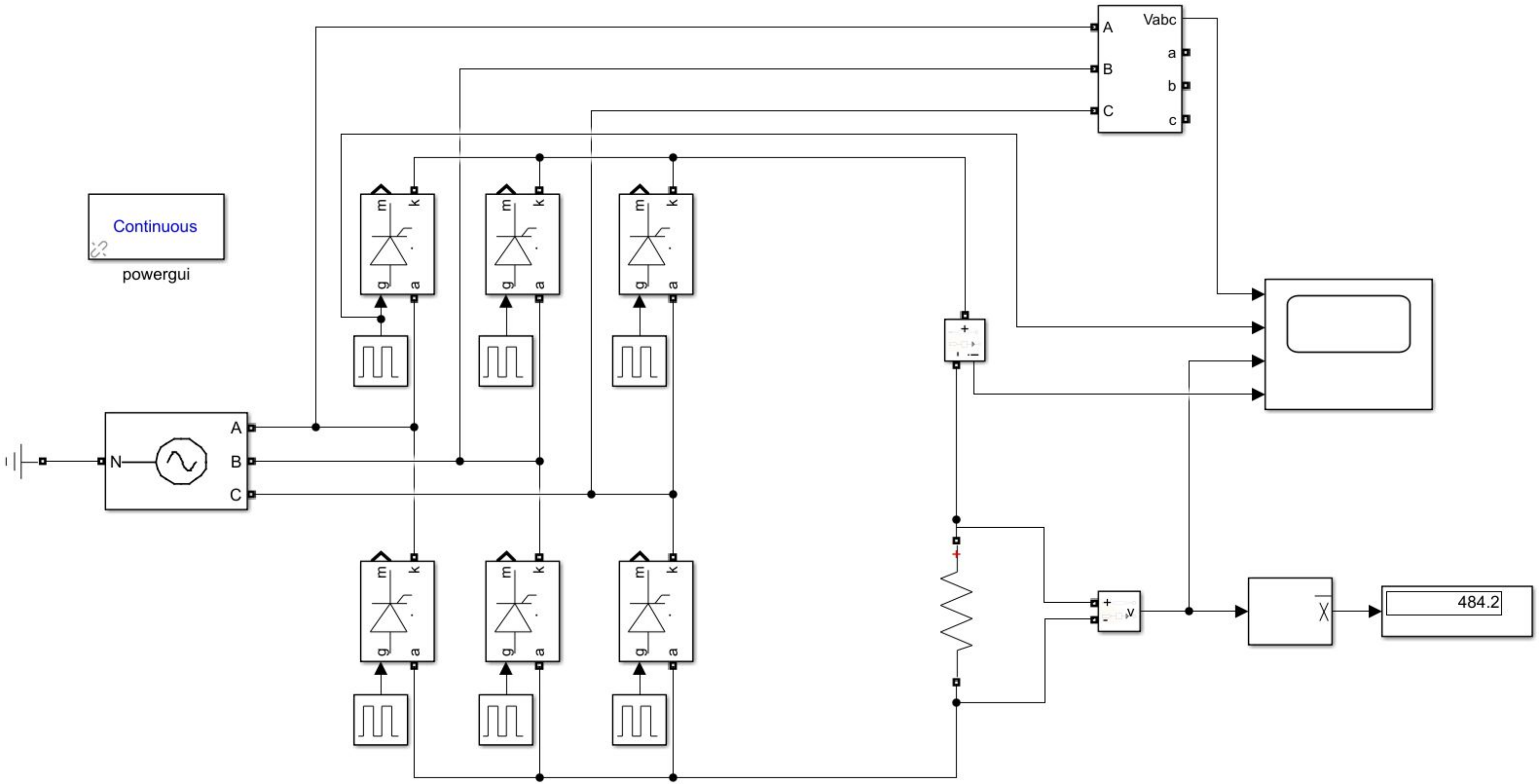

AC Measurement (Volt and angle
Grid
(3- AC or single phase AC), 50Hz
AC/DC Converter
(ref: 1,4)
Multilevel or PWM Inverter
(improved THD)
(ref: 2,6)
DC/DC Converter
(Bi-directional)
(ref: 3,5)
Traction
DC Measurement
Li-ion Battery
(Nominal Voltage 24V)
Auxiliary Load
% SOC, Current and volt
G2V mode
Grid Connection
V2G mode
Load Connection

Schedule of Work Completion

Review	Date	Expected Result
Zeroth Review	16th Jan 2022	● Completion of Literature review ● Methodology to be adopted / block diagram ● Schedule of work completion
First Review	3rd week of Feb, 2022	● 50% of the planned work to be completed ● To design and implement 3 phase grid via AC/DC full bridge converter with DC/DC converter for bidirectional charging from source to battery. ● Simulation to implement G2V configuration
Second Review	4th week of March, 2022	● 100% of the planned work to be completed ● Designing converter for bidirectional charging from battery to source via DC/DC converter or Multilevel inverter for improved performance. ● Simulation to implement V2G configuration i.e reverse charging
Final Review	1st week of May, 2022	● Project report in CAPSTONE format ● Turnitin Report for the thesis (<15%) ● Presentation of completed result to final panel review

Work Progress	
1.	3-phase fully controlled full wave bridge converter
2.	3-phase sine-PWM Inverter
3.	Model of DC-DC converter for Light-Duty Vehicles (LDV)
4.	Model of full bridge two-Quadrant converter in G2V mode
5.	Implementation of V2G (reverse Charging)
6.	Design of (on/off)-board subsystem
7.	PLL Voltage and current controller
8.	V2G-G2V operation controlled with toggle switch
9.	Parallel operation of batteries
10.	%THD (total harmonic distortion) comparison

1. 3-phase full bridge converter



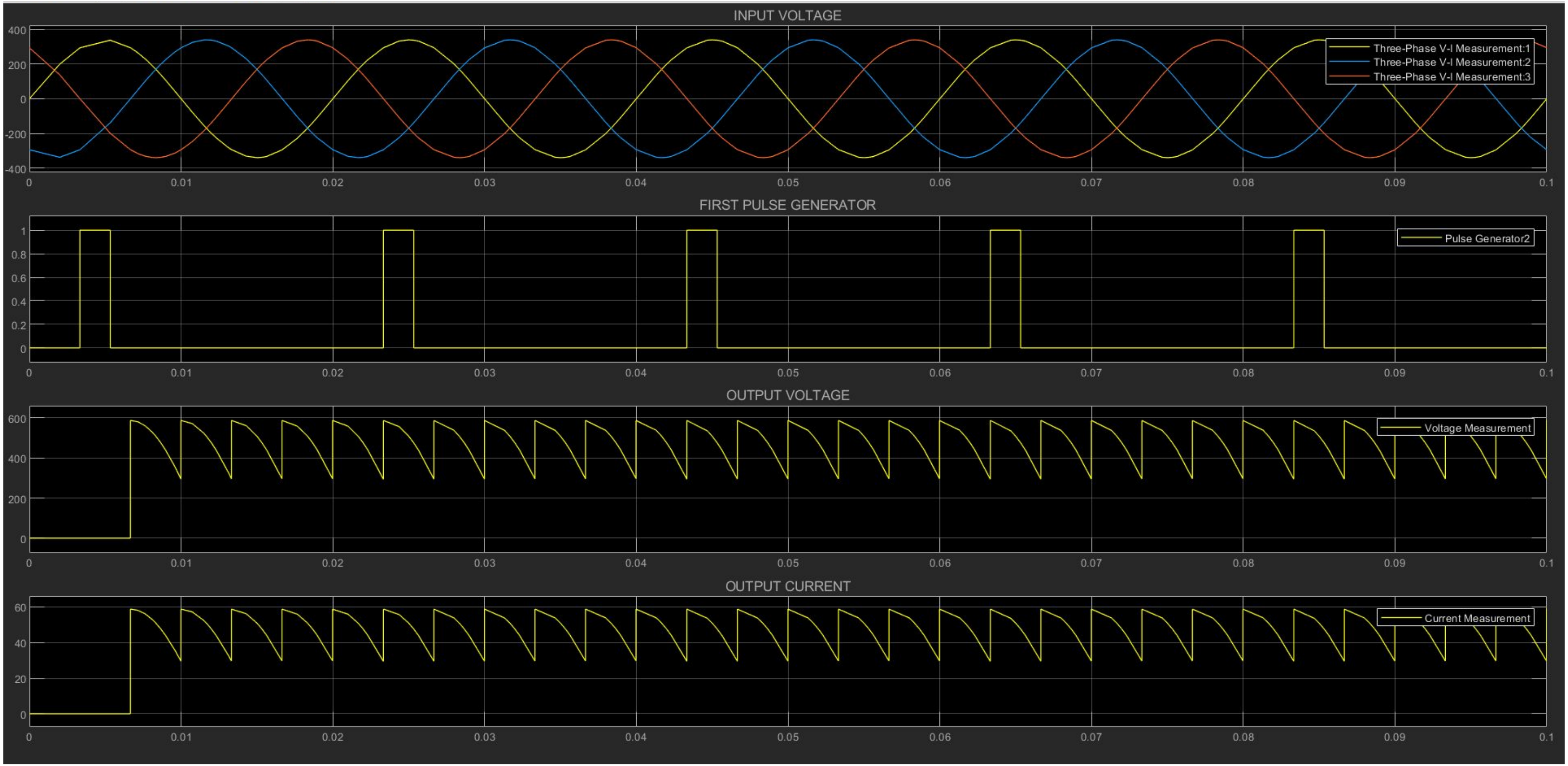
Parameters:

- **Pulse generator (T_1):** fired at (α+30°)
  - Amplitude = 1
  - Period = 0.02 sec
  - Pulse width = 10
  - Phase delay = (0.0033) i.e (α = 30°)

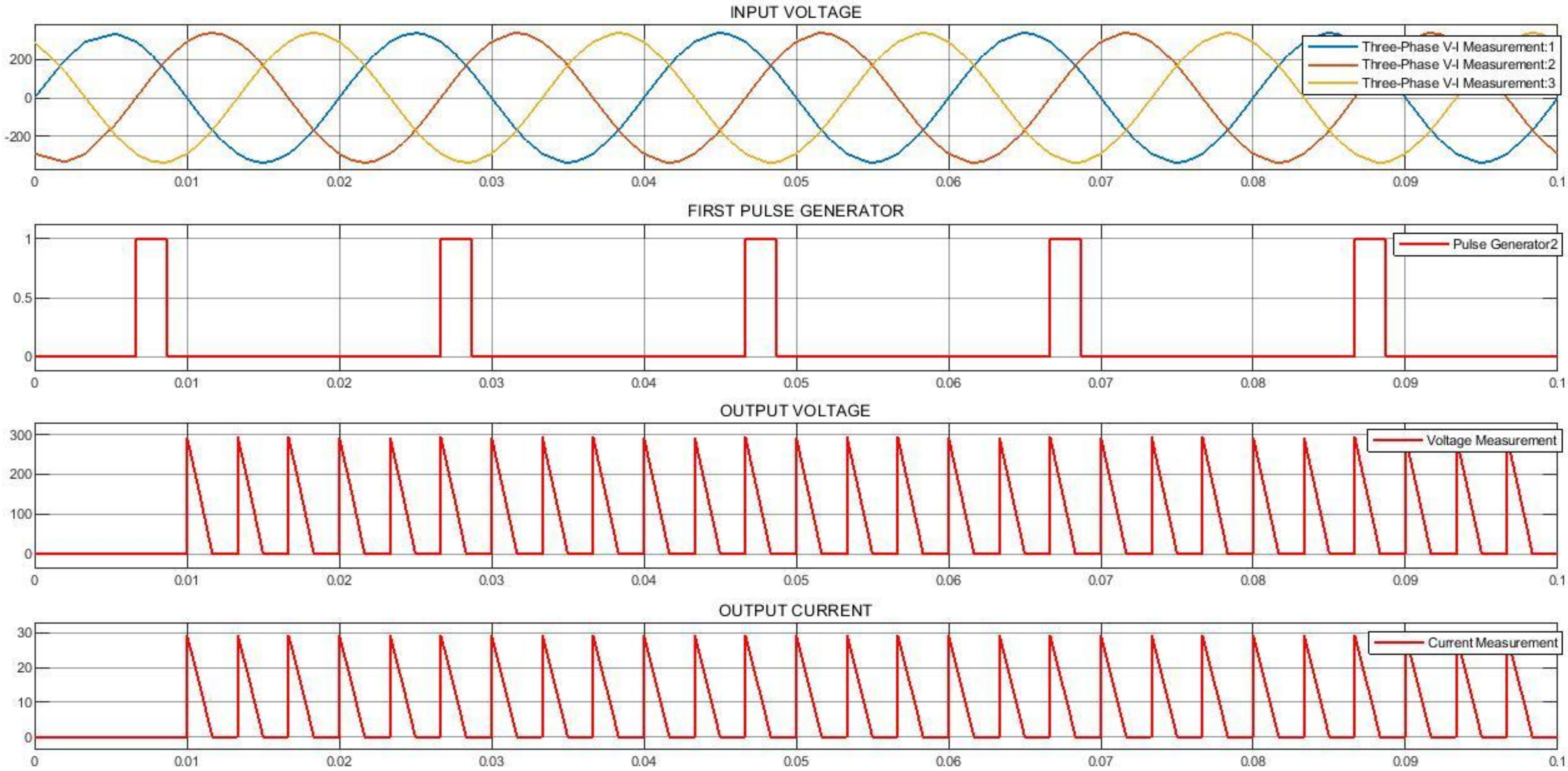
- **3-Φ Supply:**
  - V_{line}(rms): 415
  - Frequency: 50Hz

- **Resistive (Load):**
  - R=10 ohms

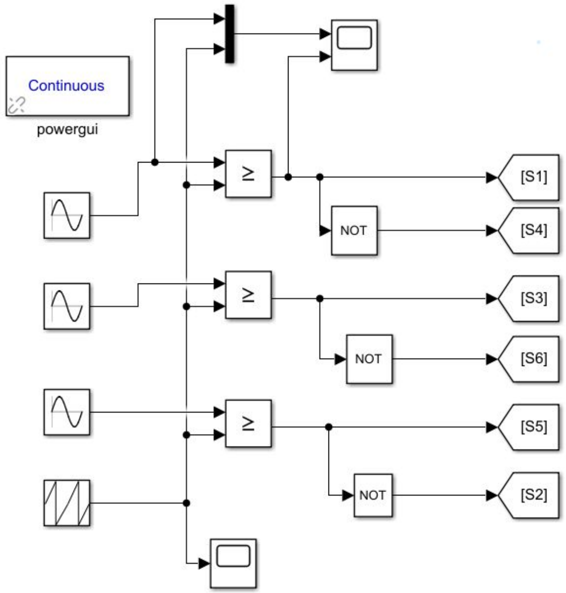
3-Phase Full Bridge converter at α = 30°

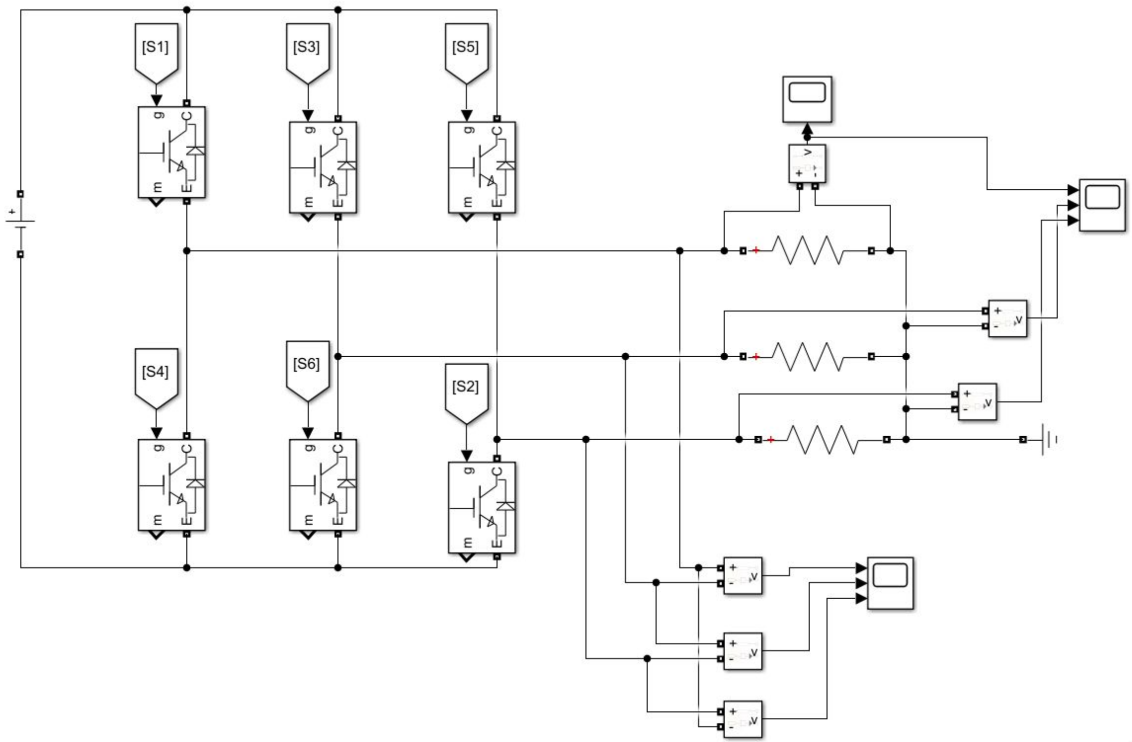


3-Phase Full Bridge converter at α = 90°



2. 3-phase PWM Inverter





Parameters:

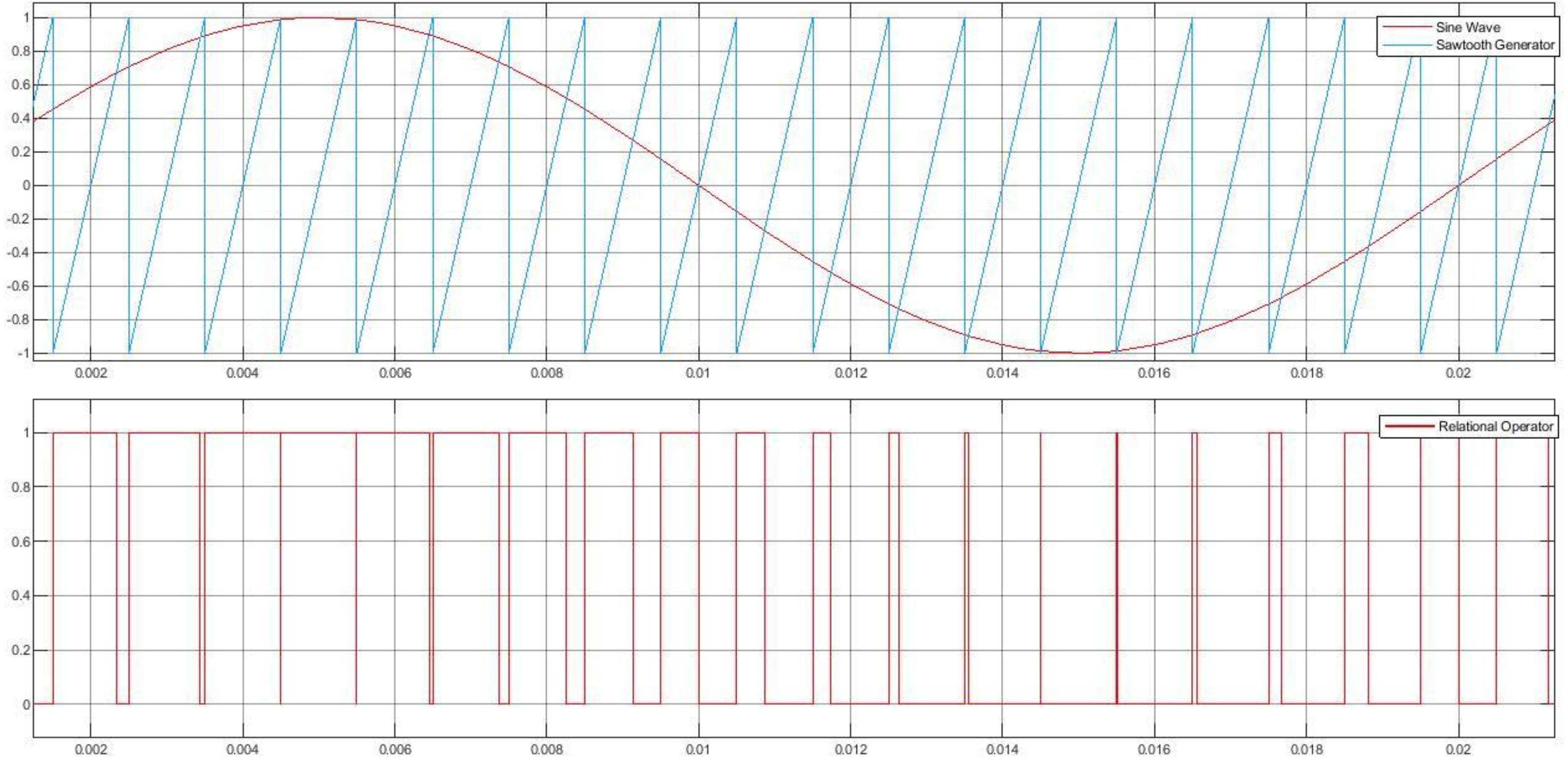
- **Sine wave:**
  - Amplitude : 1
  - Frequency (red/sec) : 2*pi*50

- **Sawtooth Generator:**
  - Frequency (Hz): 1e3
  - Phase Angle : 180°

- **DC source**
  - Volts: 100v

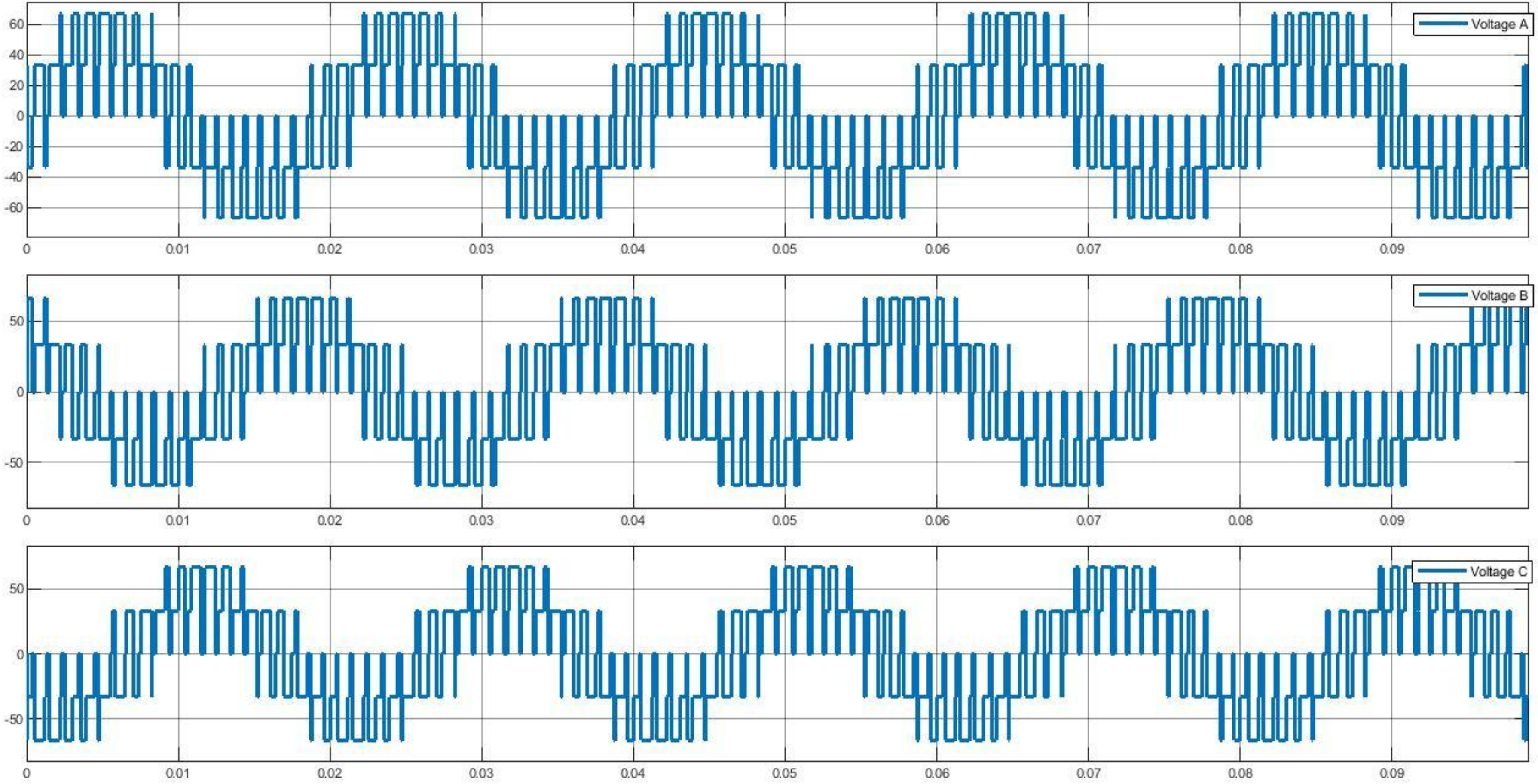
- **Resistive (Load):**
  - R=10 ohms

Input

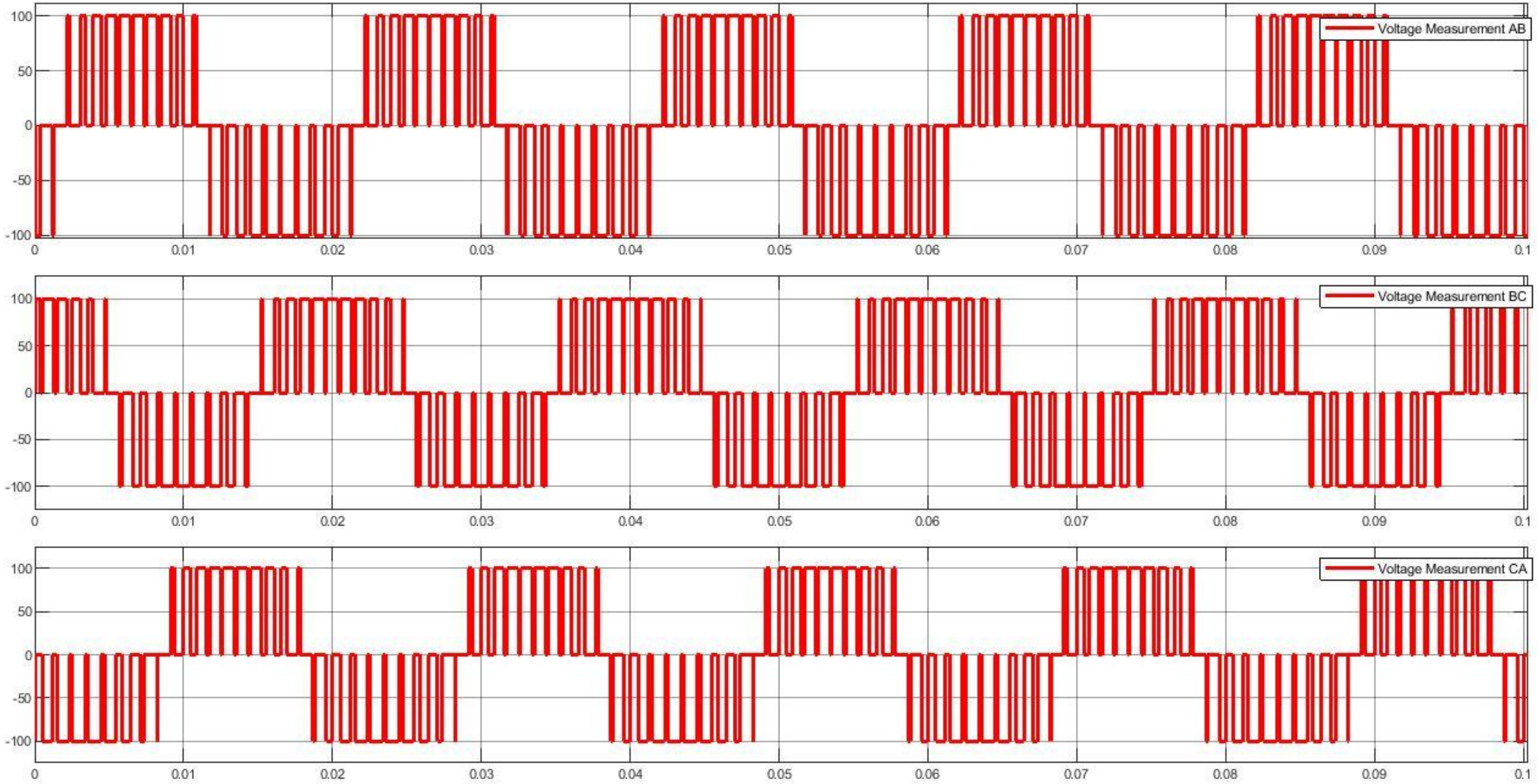


Sine Wave
Sawtooth Generator
Relational Operator
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0.002
0.004
0.006
0.008
0.01
0.012
0.014
0.016
0.018
0.02

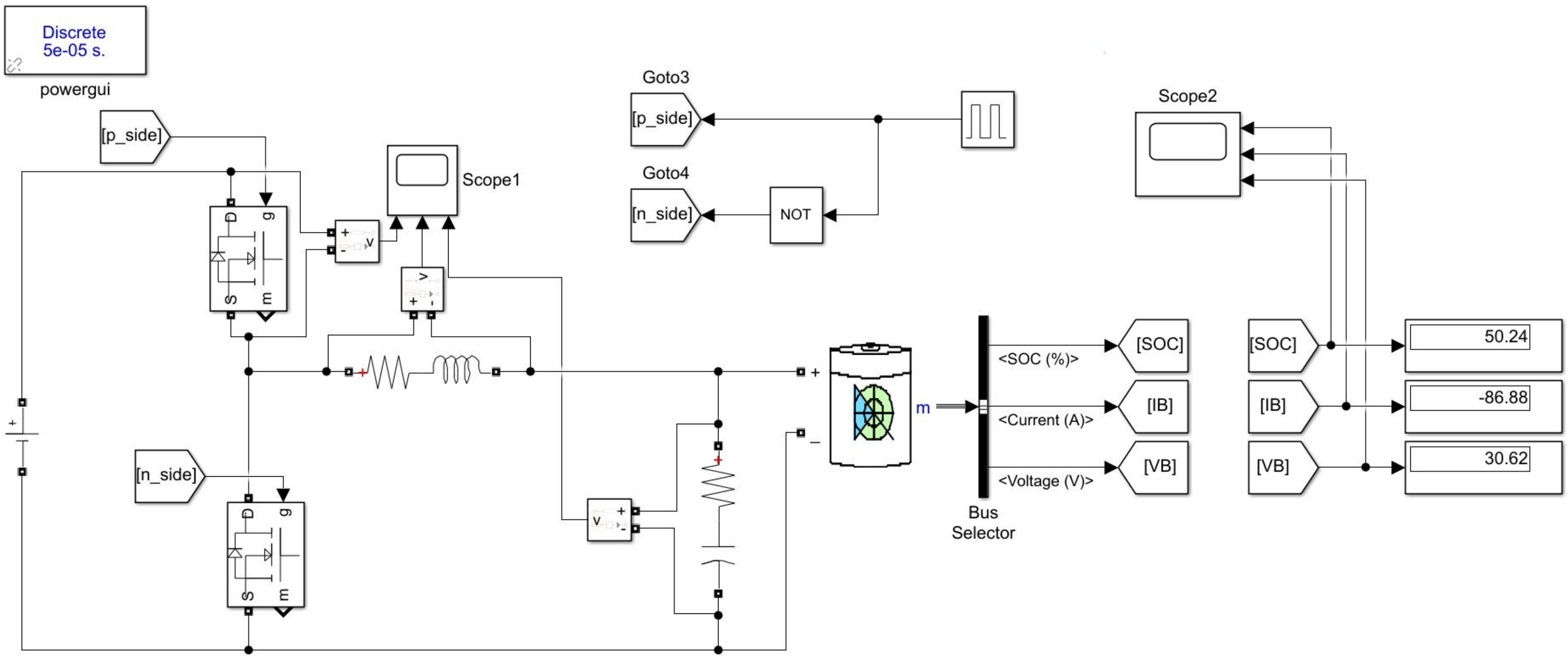
Output Phase-Voltage of three phase Inverter



Output Line voltage of three phase Inverter



3. Model of DC-DC converter for Light-Duty Vehicles (LDV)



Parameters:

- **Battery (Li-ion):**
  - Nominal Voltage (V) =24
  - Rated Capacity (Ah) = 10
  - Initial SOC = 50%
  - Battery response time (s) = 1e-4

- **DC source:**
  - Voltage (V) = 48

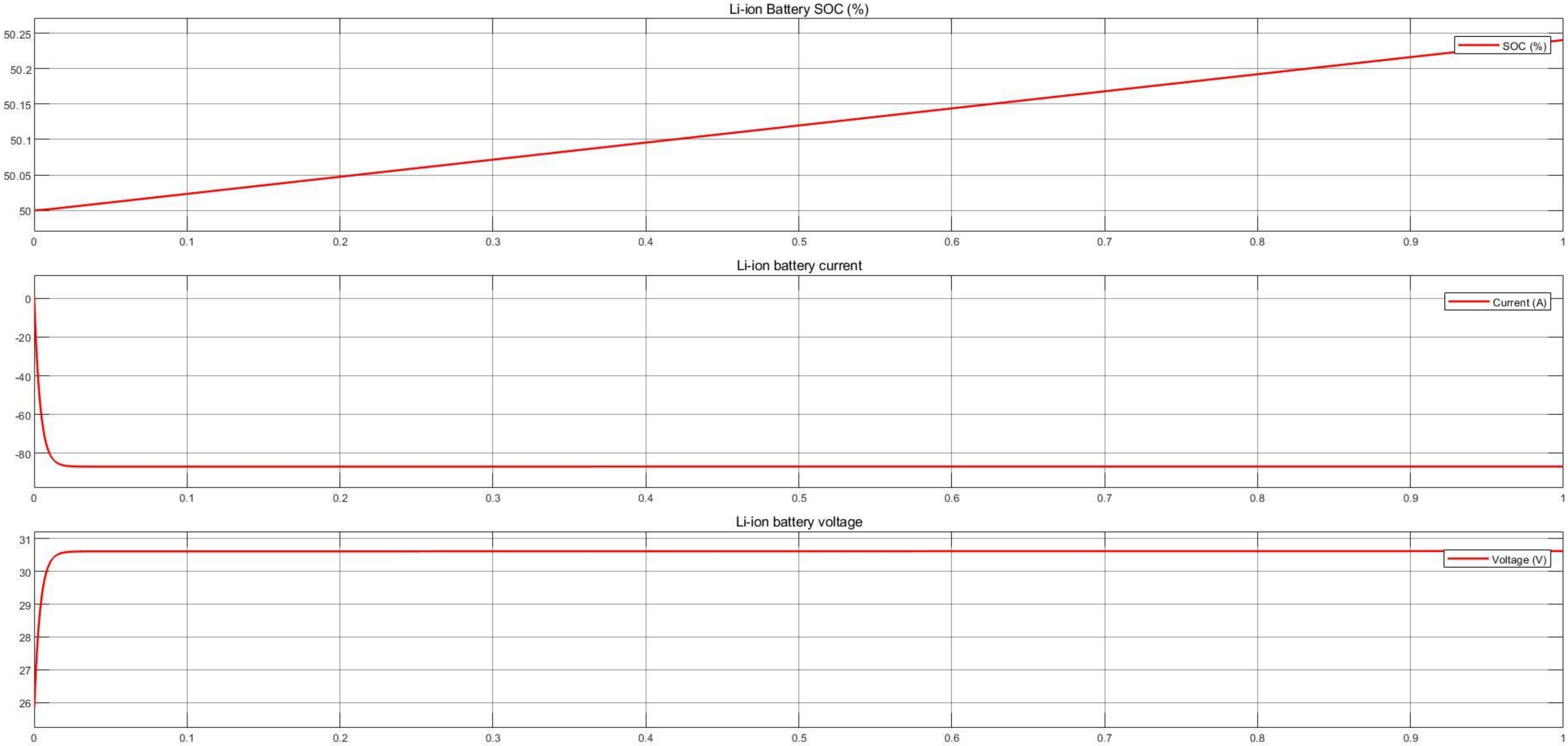
- **Load (RL):**
  - R (ohm) = 0.1
  - L (mH) = 1

- **Load (RC):**
  - R (m ohm) = 0.1
  - C (mF) = 1

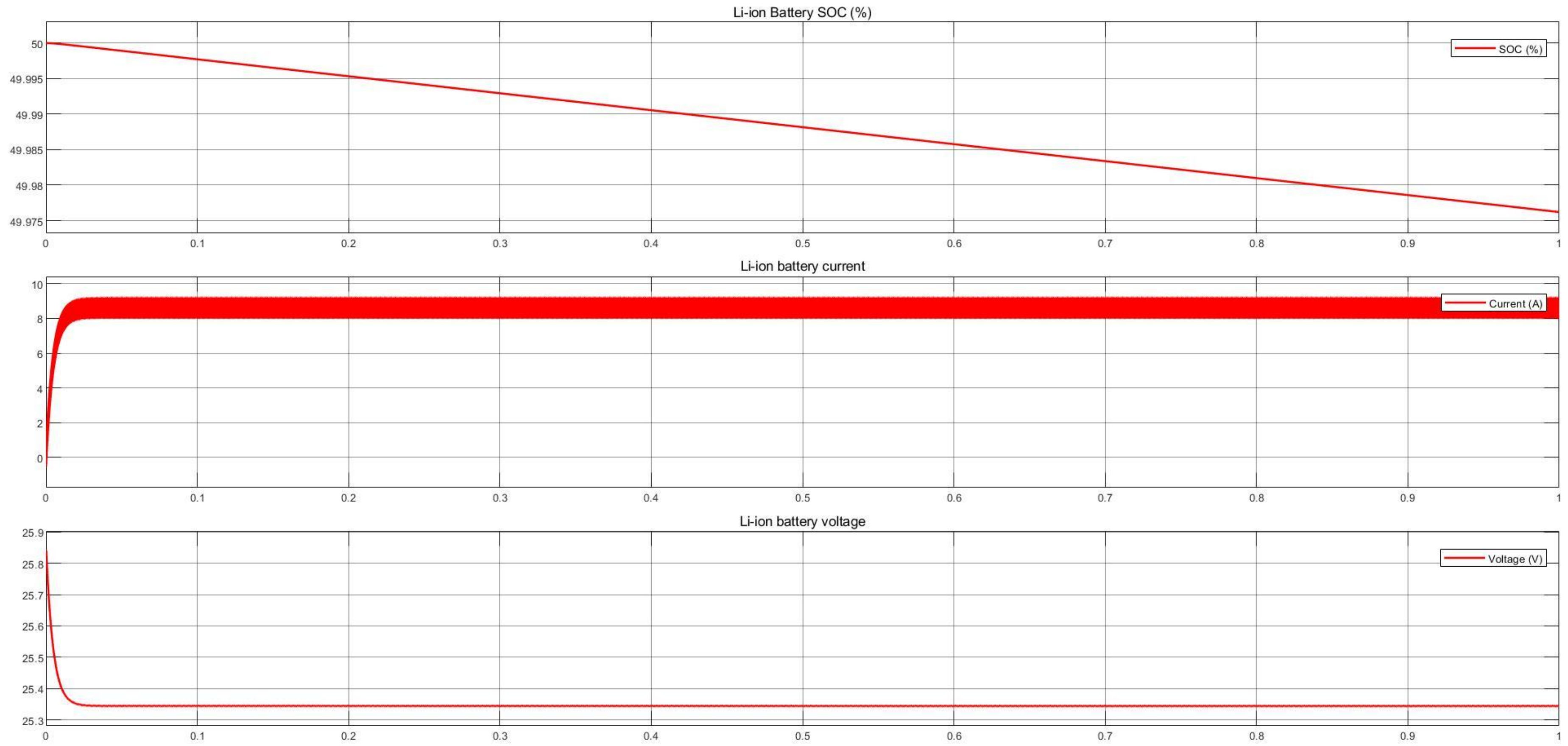
- **Charging Parameters**
  - Pulse Generator:
    - Amplitude = 1
    - Period (sec) = 1*10^-4
    - Pulse Width = 70
  - SOC = 50.24
  - I_b Current (amps) = -86.88
  - V_b (volt) = 30.62

- **Discharging Parameters**
  - Pulse Generator:
    - Amplitude = 1
    - Period (sec) = 1*10^-4
    - Pulse Width = 40
  - SOC = 49.98
  - I_b Current (amps) = 9.157
  - V_b (volt) = 25.34

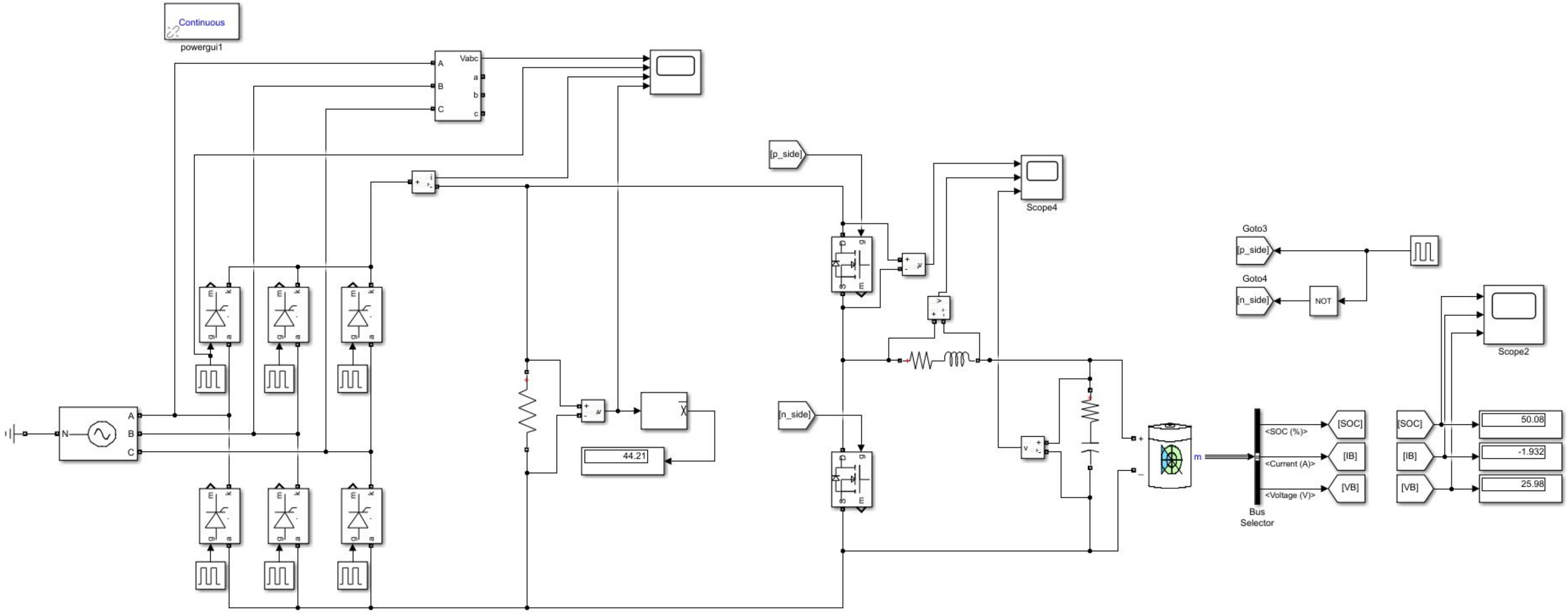
Charging Output



Discharging Output



4. Model of full bridge two-Quadrant converter in G2V mode



Parameters:

- **Battery:**
  - Nominal Voltage (V) =24
  - Rated Capacity (Ah) = 10
  - Initial SOC = 50%
  - Battery response time (s) = 1e-4

- **Load (RL):**
  - R (ohm) = 0.1
  - L (mH) = 1

- **Load (RC):**
  - R (m ohm) = 0.1
  - C (mF) = 1

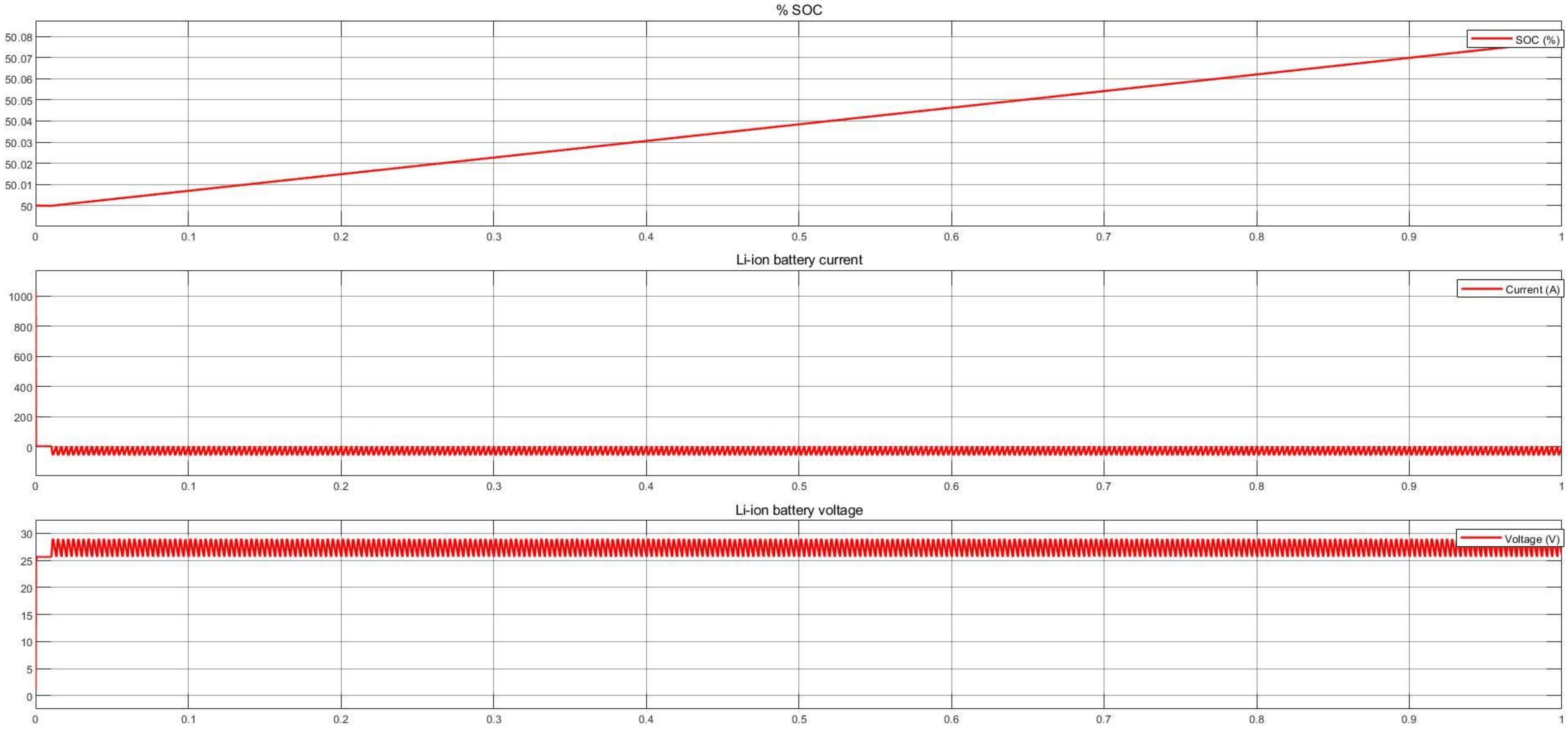
- **3 Phase AC source:**
  - Phase Voltage (V_{rms}) = 230
  - Line Voltage (V_{rms}) = 398
  - Frequency (Hz) = 50

- **Pulse generator (thyristor T_1):**
  - Amplitude = 1
  - Period (sec) = 0.02
  - Pulse Width = 10
  - Phase delay = (1.666e-3)+(5.388e-3)

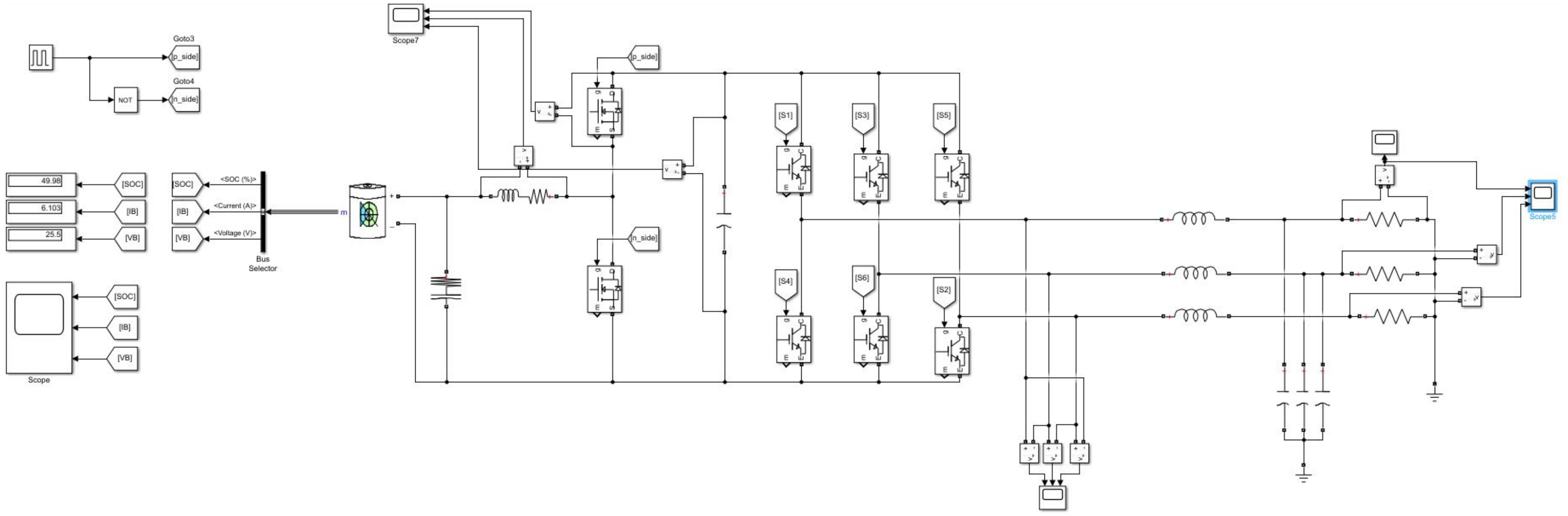
- **Pulse generator (MOSFET M_1):**
  - Amplitude = 1
  - Period (sec) = 1e-4
  - Pulse Width = 70
  - Phase delay = 0

- **ΔVmax = 2%**
- **ΔImax = 10%**

Charging Output



5. Implementation of V2G (reverse Charging)



Parameters:

- **Battery:**
  - Nominal Voltage (V) =24
  - Rated Capacity (Ah) = 10
  - Initial SOC = 50%
  - Battery response time (s) = 1e-4

- **Load (RL):**
  - R (ohm) = 0.1
  - L (mH) = 1

- **Load (RC):**
  - R (m ohm) = 0.1
  - C (mF) = 1

- **3 Phase AC source:**
  - Phase Voltage (V_{rms}) = 230
  - Line Voltage (V_{rms}) = 398
  - Frequency (Hz) = 50

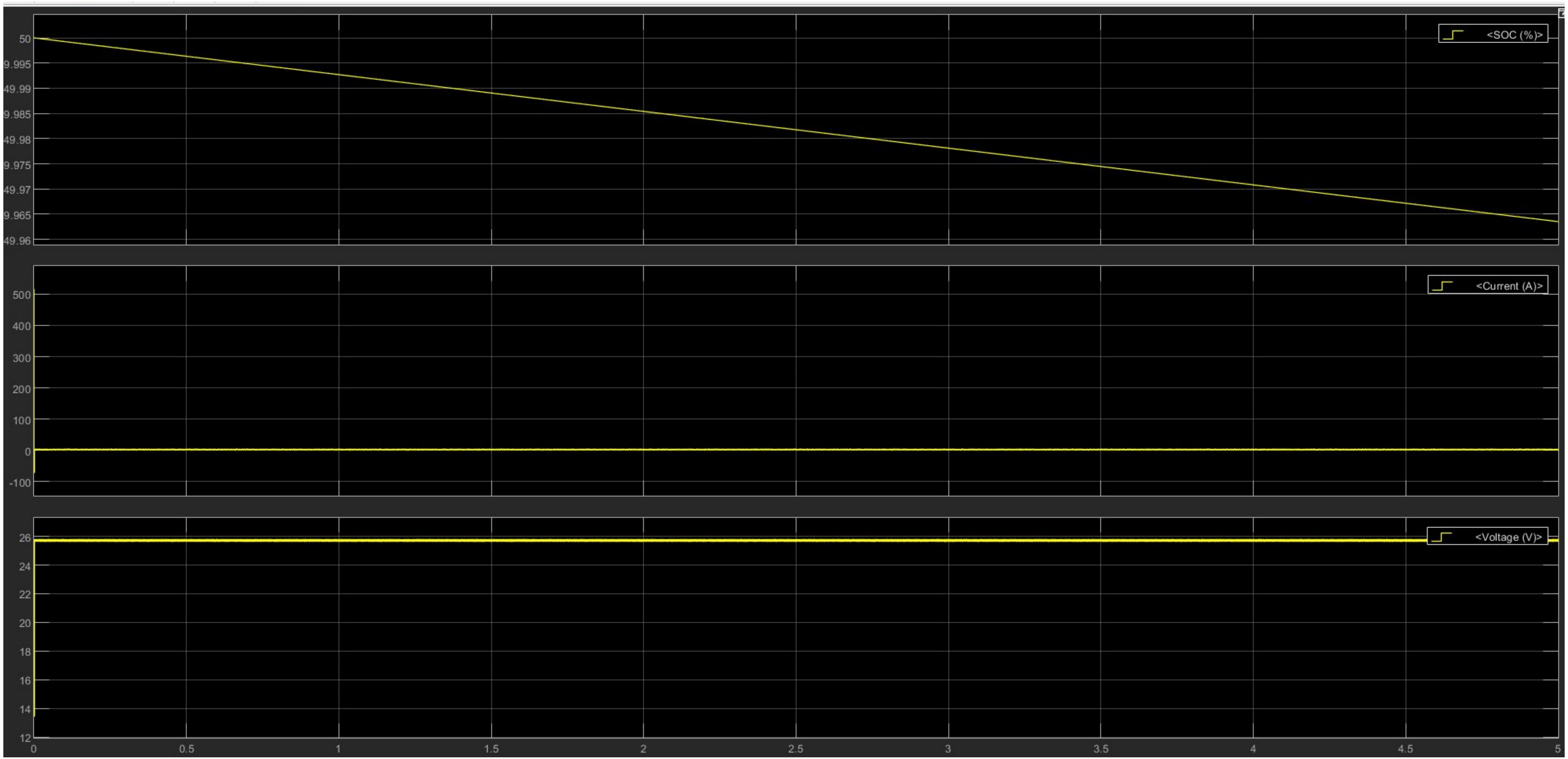
- **Pulse generator (thyristor T_1):**
  - Amplitude = 1
  - Period (sec) = 0.02
  - Pulse Width = 10
  - Phase delay = (1.666e-3)+(5.388e-3)

- **Pulse generator (MOSFET M_1):**
  - Amplitude = 1
  - Period (sec) = 1e-4
  - Pulse Width = 70
  - Phase delay = 0

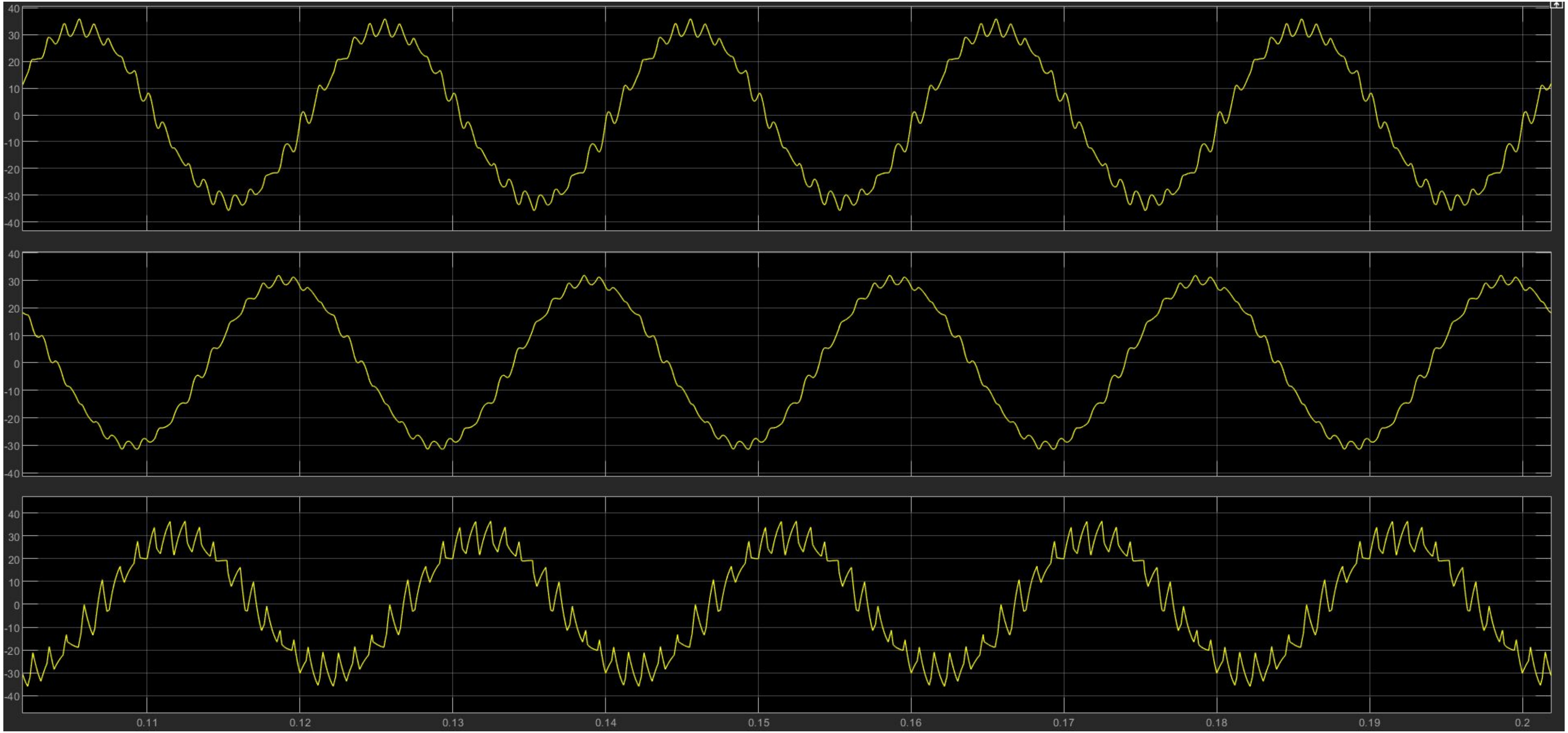
- **Grid Filter**
  - LCL = (5mH, 30uF, 5mH)

- **ΔVmax = 2%**
- **ΔImax = 10%**

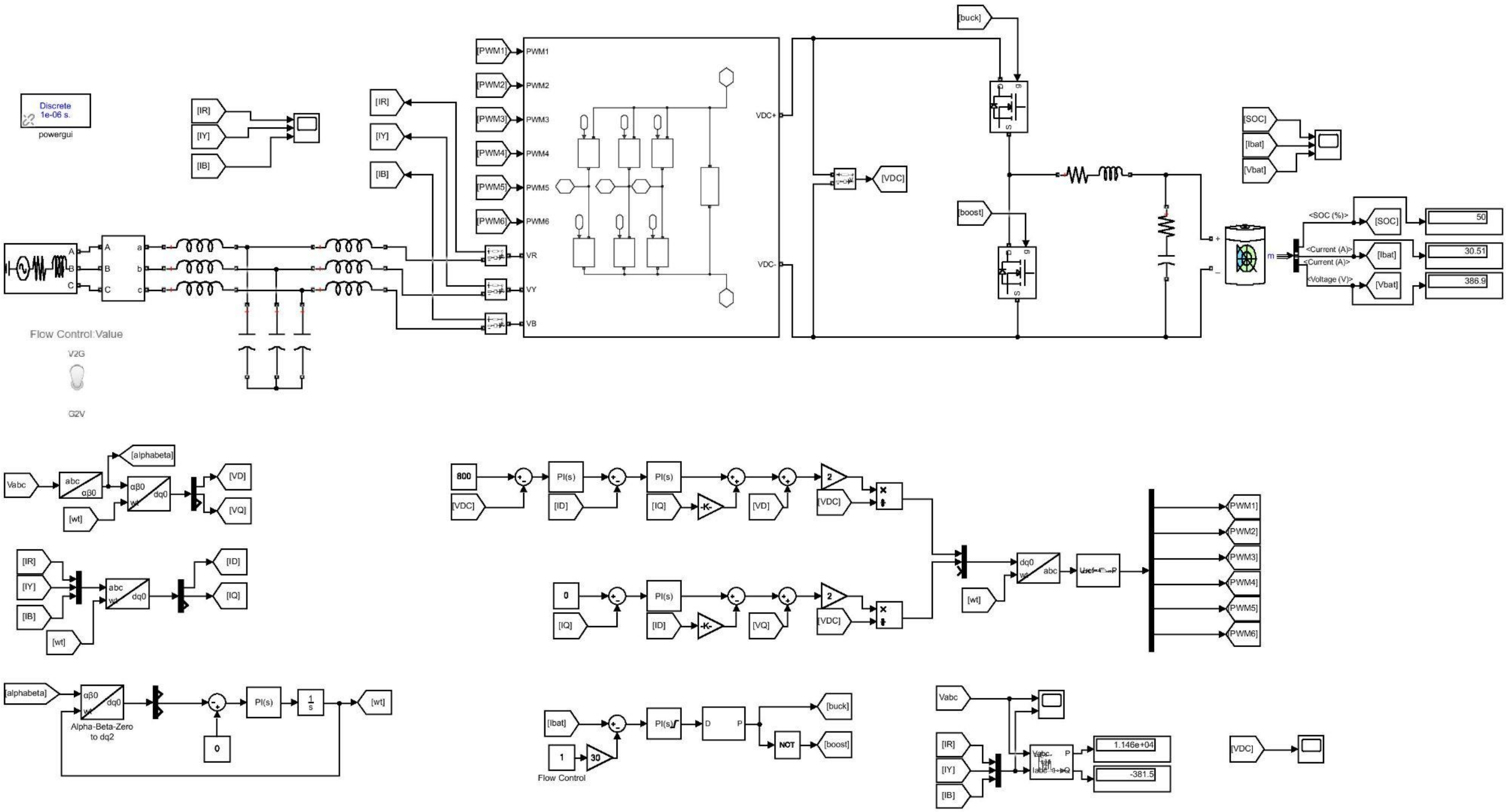
Battery Status Output:



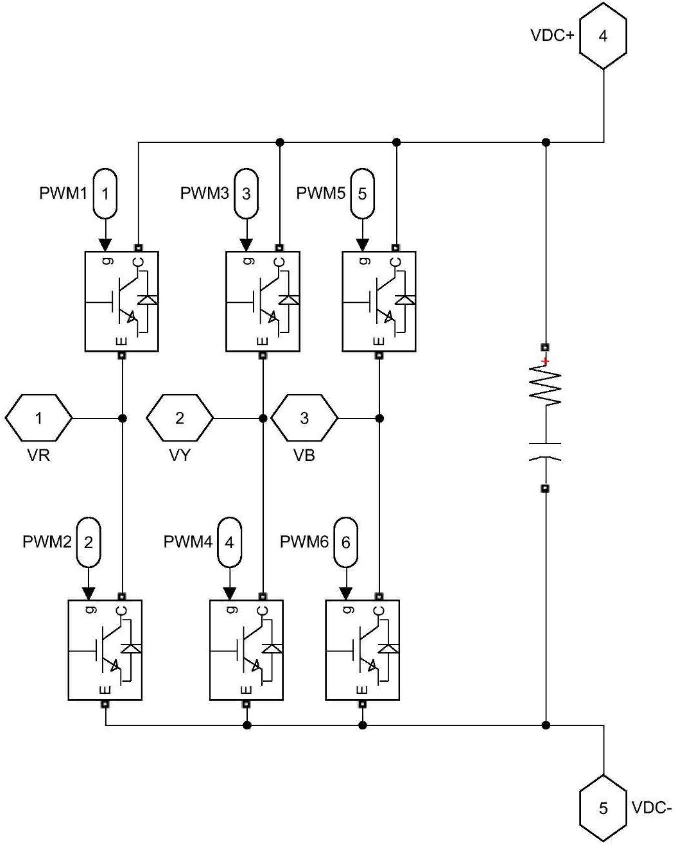
Output (Phase voltage of V2G)



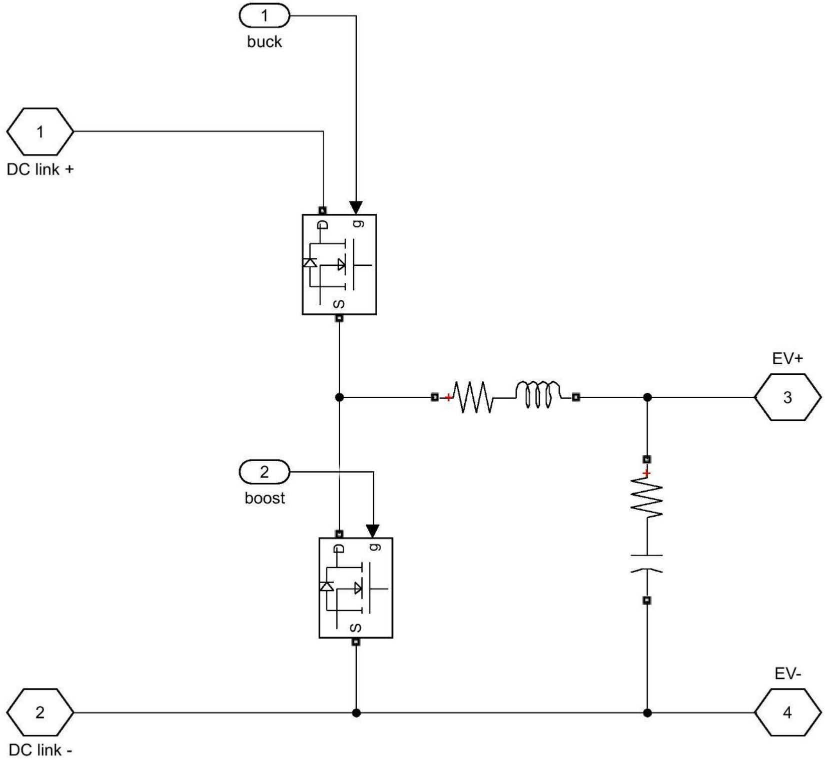
6. Design of (on/off)-board subsystem



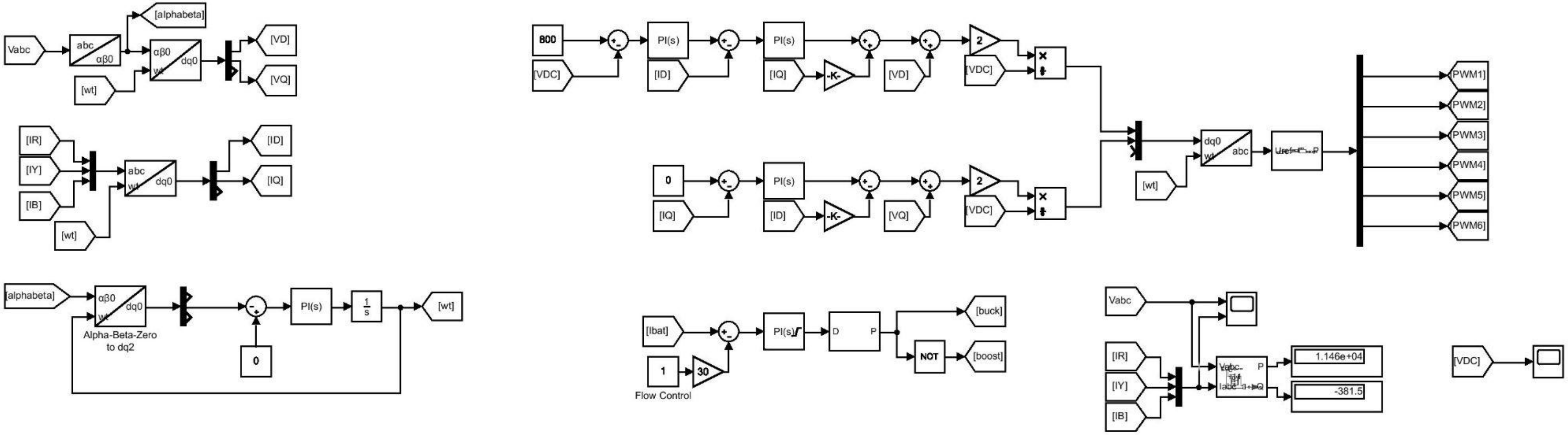
Subsystem: 3 phase converter bidirectional AC/DC converter



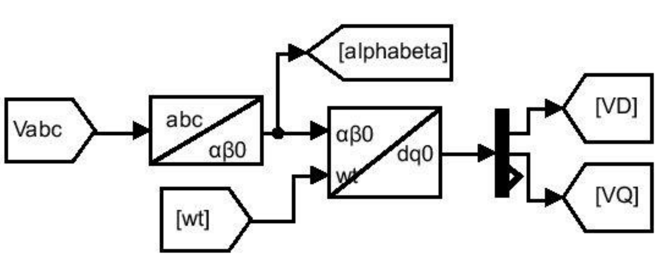
<u>Subsystem</u>: DC/DC Switch

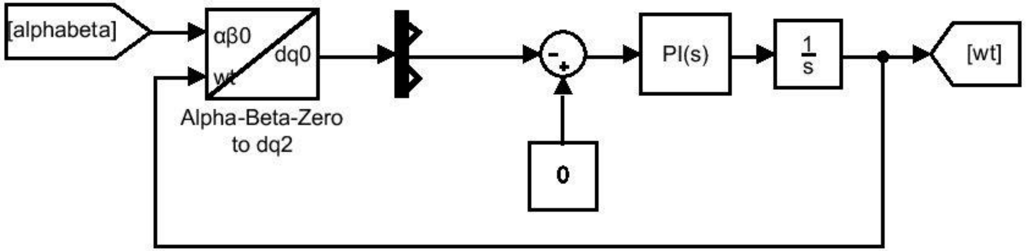


7. Phase-locked-loop (PLL)
Voltage and current controller



PLL - Voltage controller





Measured Values

- $V_a = V_{grid} \mathrm{Sin}(wt)$
- $V_b = V_{grid} \mathrm{Sin}(wt-2\pi/3)$
- $V_c = V_{grid} \mathrm{Sin}(wt-4\pi/3)$

PLL

- $Vq_{(ref)}=0$ [required condition for phase lock]
- Output = wt
- PI= (10,50000)

Transforming Voltage

(Clarks) (Park)

- $\mathbf{V_{abc}} \Rightarrow \mathbf{V_{\alpha\beta 0}} \Rightarrow \mathbf{V_{dq0}}$

$$\begin{pmatrix} V_d \\ V_q \end{pmatrix} = \frac{2}{3} \begin{pmatrix} \mathrm{Cos}(\theta) & \mathrm{Cos}(\theta-2\pi/3) & \mathrm{Cos}(\theta+2\pi/3) \\ -\mathrm{Sin}(\theta) & -\mathrm{Sin}(\theta-2\pi/3) & -\mathrm{Sin}(\theta+2\pi/3) \end{pmatrix} \begin{pmatrix} V_a \\ V_b \\ V_c \end{pmatrix}$$

Generating current reference signal

- Sin(wt)=Active
- Cos(wt)=Reactive

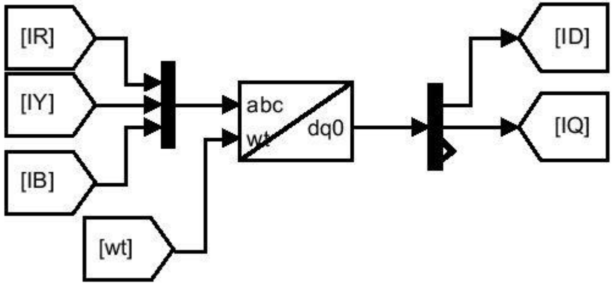
- Active component aligned in phase with alpha (α).
- Reactive component aligned in phase with beta (β).
- <u>Active power injection:</u>
    - Current in phase with reference voltage
- <u>Reactive power injection:</u>
    - Current 90° out of phase with reference current

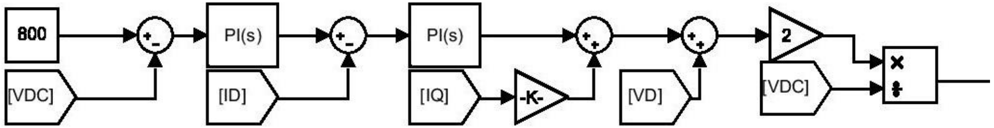
As for V2G => $V_{INV} = V_G + V_L$ ....(Phasor Sum)

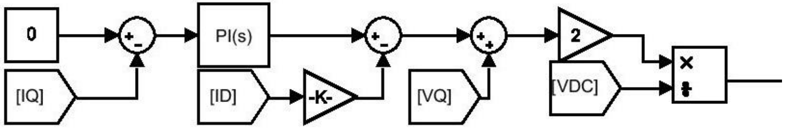
- Active current :
    - $|V_G| \approx |V_{INV}|$ with small phase difference as per direction of flow
- Reactive current [lagging] injection:
    - $|V_{INV}|>|V_G|$ and $\angle V_{INV}=\angle V_G$
- Reactive current [leading] injection:
    - $|V_{INV}|<|V_G|$ and $\angle V_{INV}=\angle V_G$

Advantageous over open loop system which is mere algebraic and might not withstand conditions like harmonics, surges, noise, spikes.

PLL - Current controller





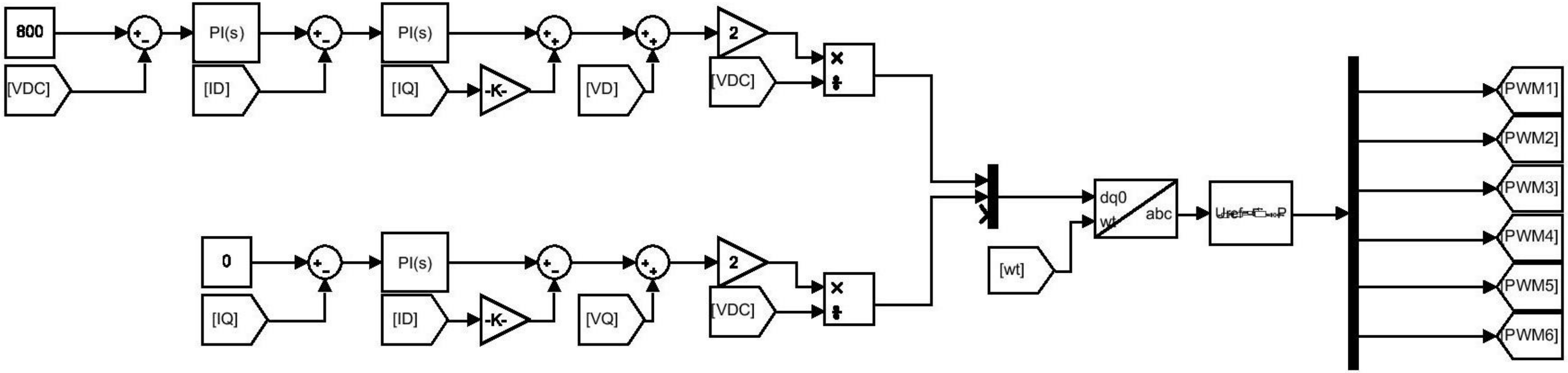


Id (Active current)

1. Compare VDC with VDC_{ref}(=800)
2. Generated Id_{ref} through PI (0.5,5) controller
3. Compare Id with Id_{ref}
4. Generated U_d through PI (25,500) controller
5. Add Vd +LωIq
6. Multiply by 2/VDC
7. This give modulation index m_d as ($V_d = m_d$*VDC/2)

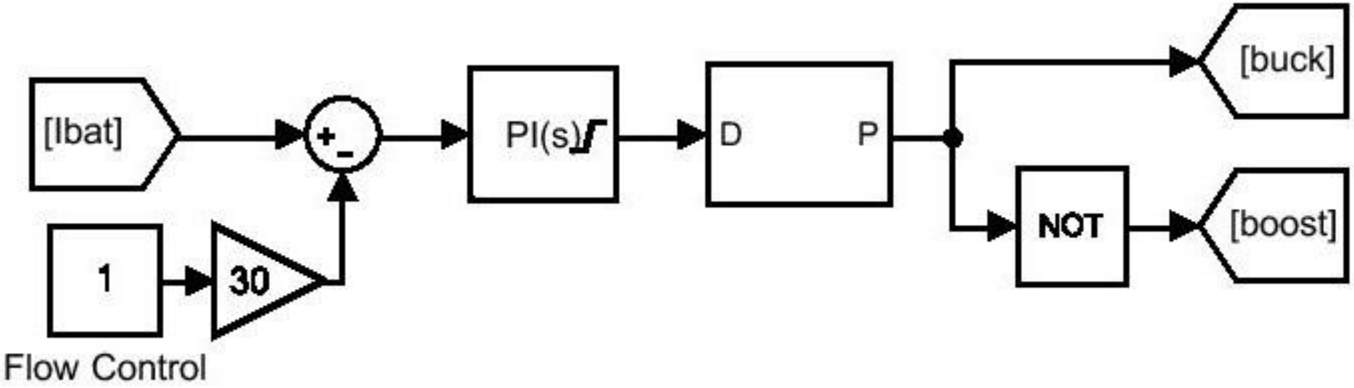
Iq (Reactive current)

1. Compare Iq with Iq_{ref} =0
2. Error then though PI (25,500) is U_q added with
3. Add Vd - LωId
4. Multiply by 2/VDC
5. This give modulation index m_q as ($V_q = m_q$*VDC/2)



- Transform this (m_d, m_q) to (a,b,c) for 2-level PWM generator (10KHz)
- Sine PWM switching with unipolar scheme is used
- Which are given to PWM switches [S_1, S_2, S_3, S_4, S_5, S_6] of bidirectional AC/DC subsystem

Battery charging/discharging



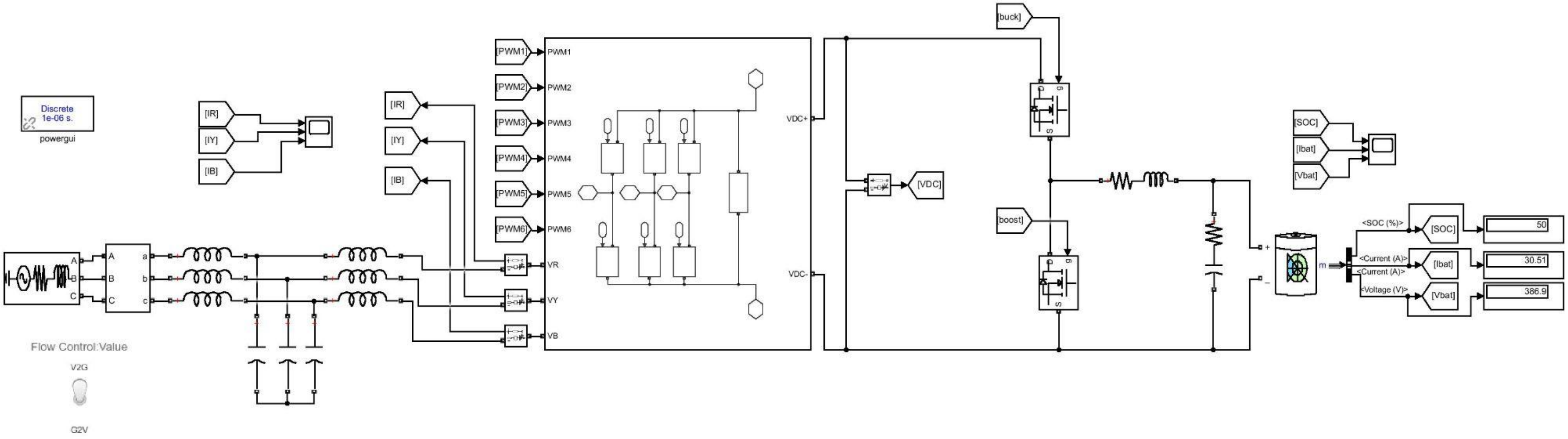
Charging

- Battery current Ibat is compared with $Ibat_{ref}$.
- (Ibat Ref = 30 Amp)
- Then through PI (0.005,10) controller with limiter (0,0.95) to DC-DC PWM generator (10KHz)
- Signals are given to buck and boost mosfets

Discharging

- Battery current Ibat is compared with $-Ibat_{ref}$.
- ($-Ibat_{ref}$ = -30 Amp)
- Then through PI (0.005,10) with limiter (0,0.95) to DC-DC PWM generator (10KHz)
- Signals are given to buck and boost mosfets

8. V2G-G2V operation controlled with toggle switch



Parameters:

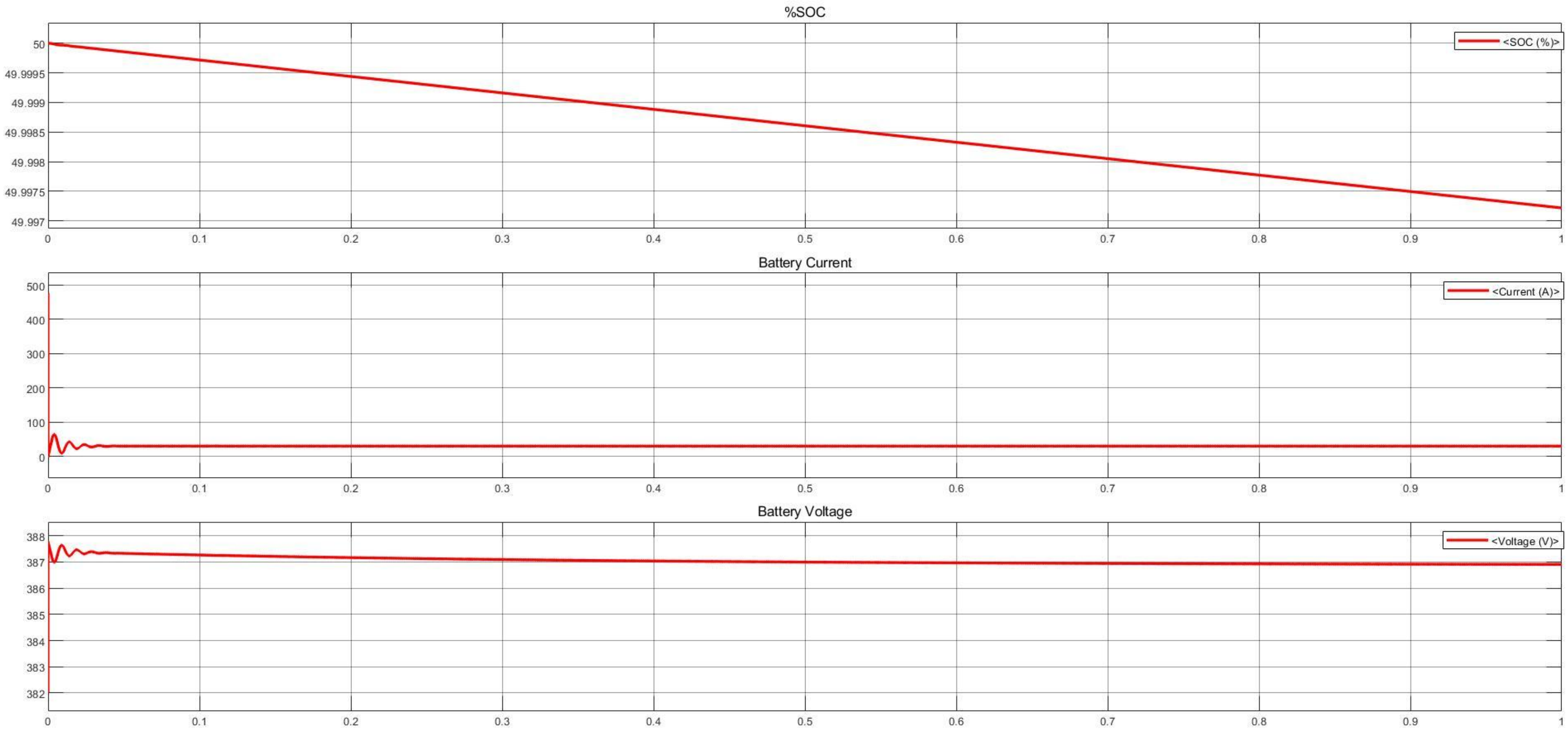
- **Battery:**
  - Nominal Voltage (V) =360
  - Rated Capacity (Ah) = 300
  - Initial SOC = 50%
  - Battery response time (s) = 1
- **Load (RL):**
  - R (ohm) = 0.1e-3
  - L (mH) = 20
- **Load (RC):**
  - R (ohm) = 0.1e-3
  - C (mF) = 0.625
- **3 Phase AC source:**
  - Line Voltage (V_{rms}) = 415
  - Frequency (Hz) = 50
- **DC link**
  - Capacitor = 5600uF
  - Resistor = 1e-3 Ohm
- **Grid Filter**
  - LCL = (5mH, 30uF, 5mH)
- **Switching Freq**
  - IGBT = 10KHz
- **Rated Power = 10KW**

<u>Operations:</u>

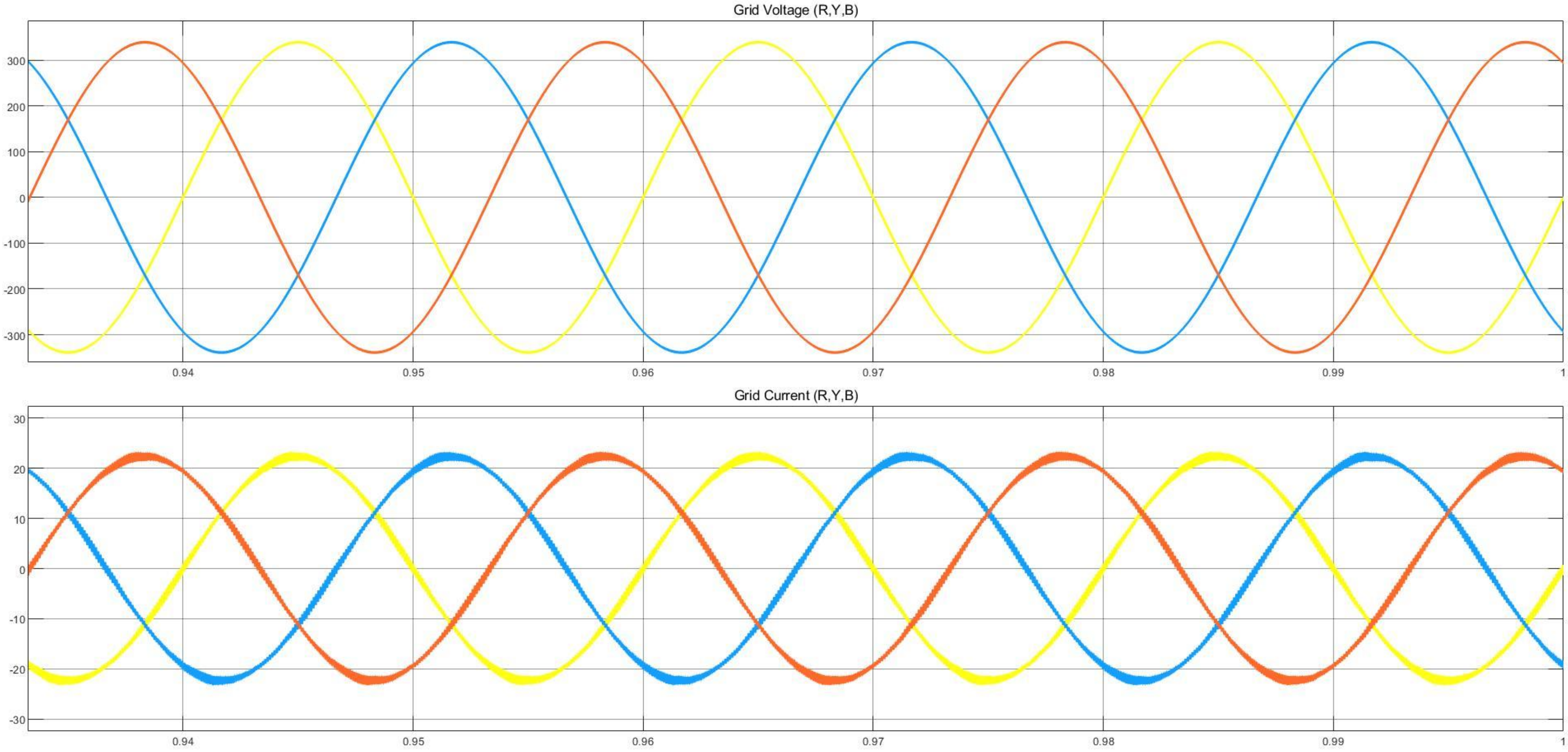
- **<u>With current reference +30 amp:</u>**
    - Active power (P) = +ve
    - Active power flow out i.e [BATTERY ➜ GRID]
    - Both Voltage and Current are **in** phase
    - SOC => <u>Decreases</u>
    - Injecting power to Grid
    - **V2G** operation

- **<u>With current reference -30 amp:</u>**
    - Active power (P) = -ve
    - Active power flow in i.e [GRID ➜ BATTERY]
    - Both Voltage and Current are **out** of phase by 180°
    - SOC => <u>Increases</u>
    - Charging of battery
    - **G2V** operation

V2G: Battery Status

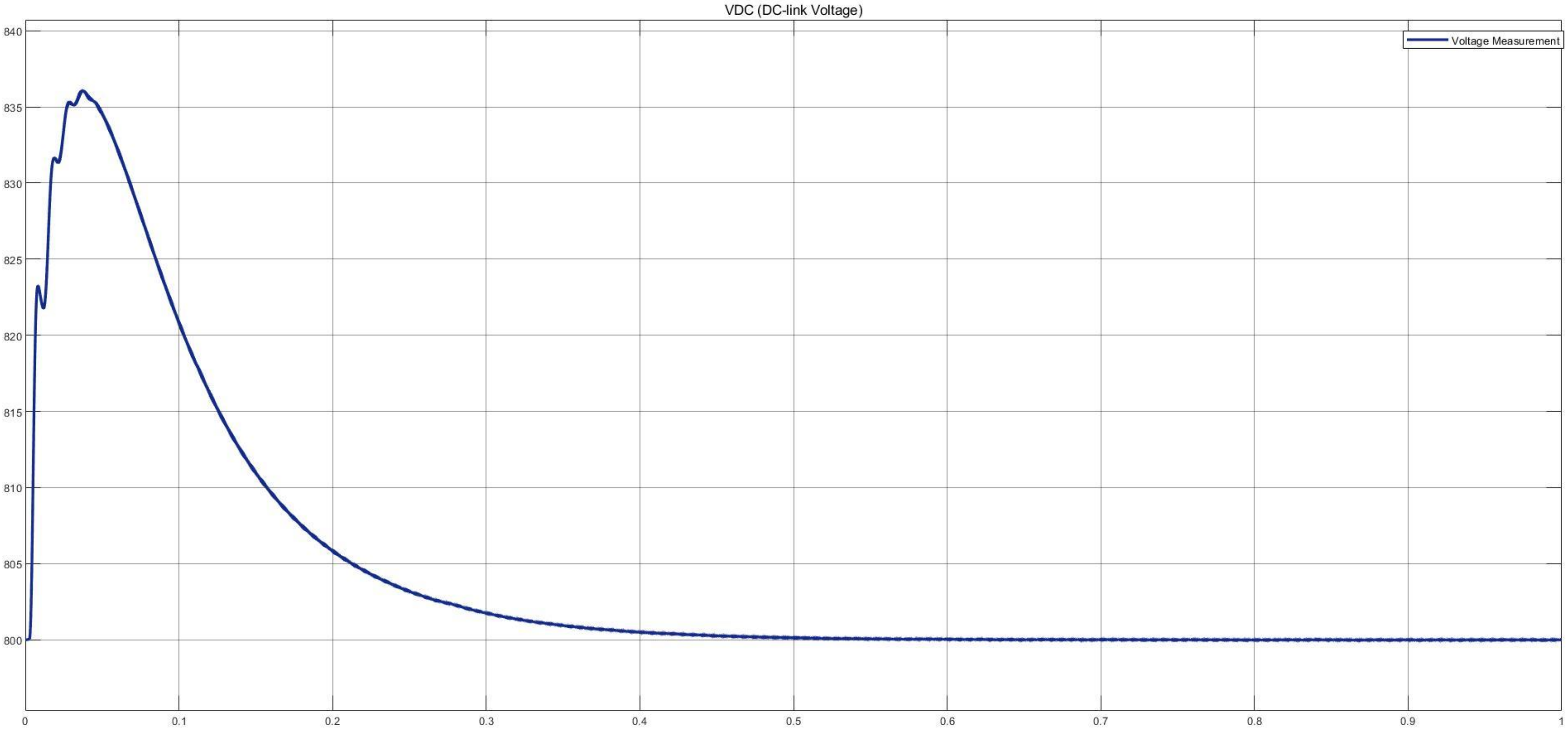


V2G: Grid

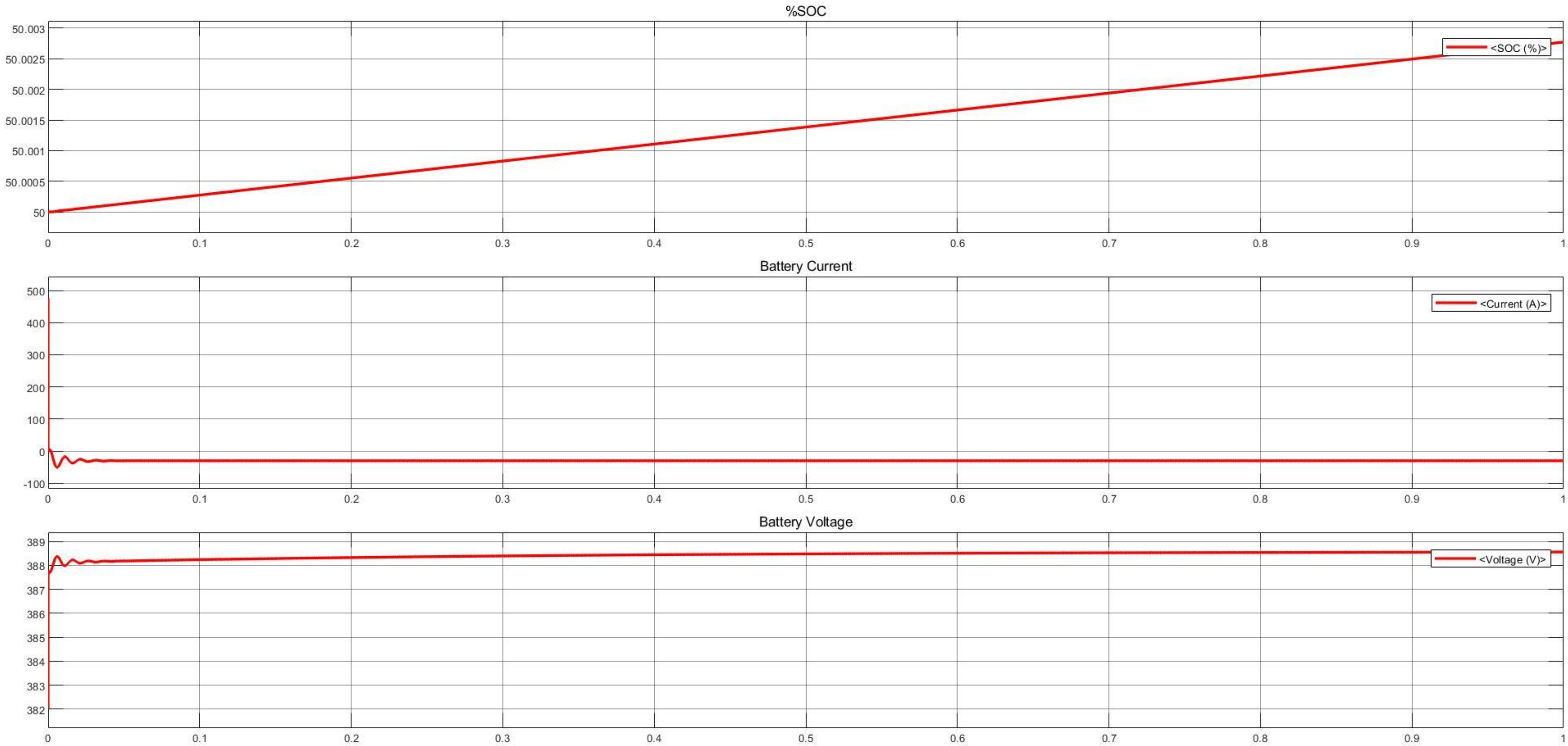


Grid Voltage (R,Y,B)
300
200
100
0
-100
-200
-300
0.94
0.95
0.96
0.97
0.98
0.99
1
Grid Current (R,Y,B)
30
20
10
0
-10
-20
-30
0.94
0.95
0.96
0.97
0.98
0.99
1

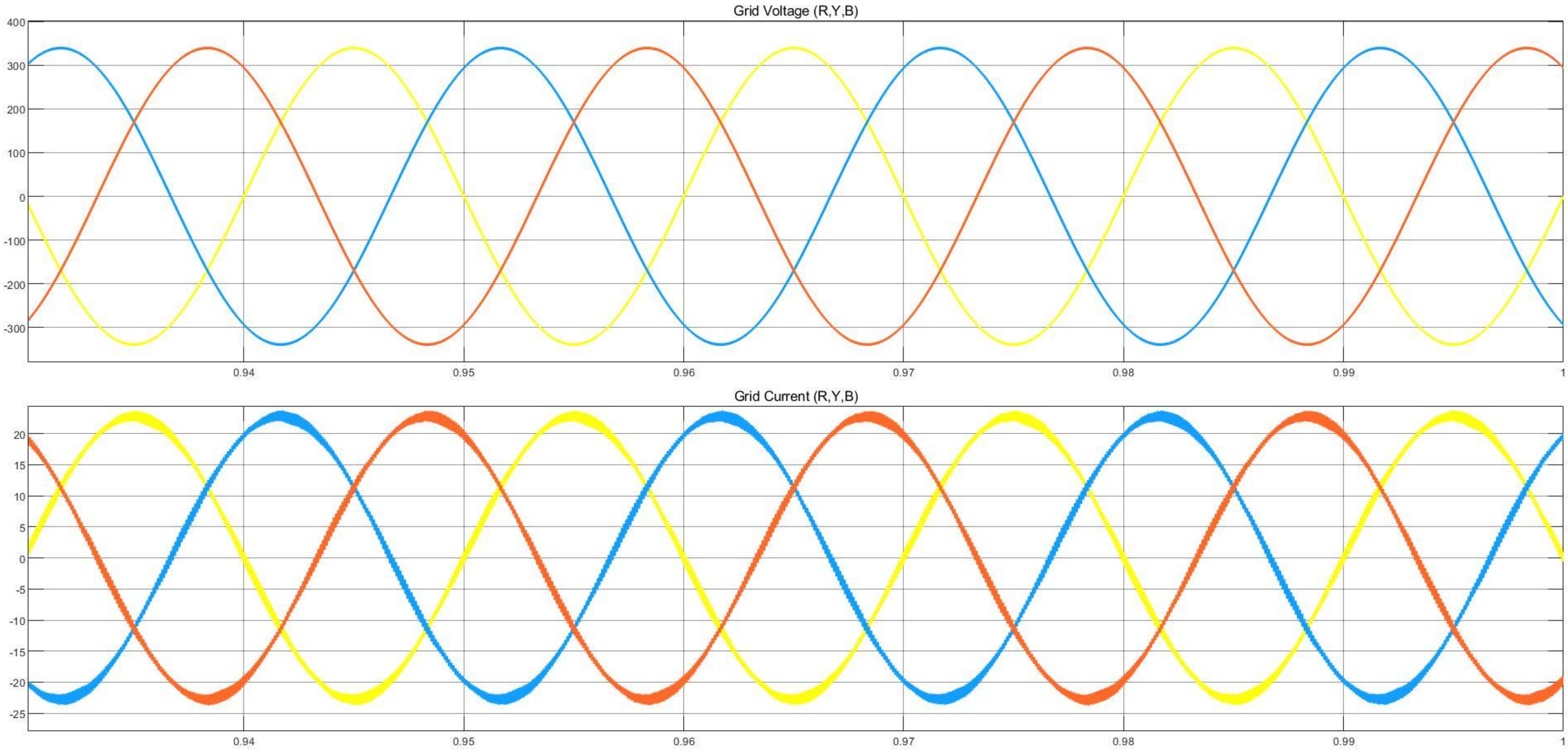
V2G: Vdc


VDC (DC-link Voltage)
Voltage Measurement
840
835
830
825
820
815
810
805
800
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

G2V: Battery Status

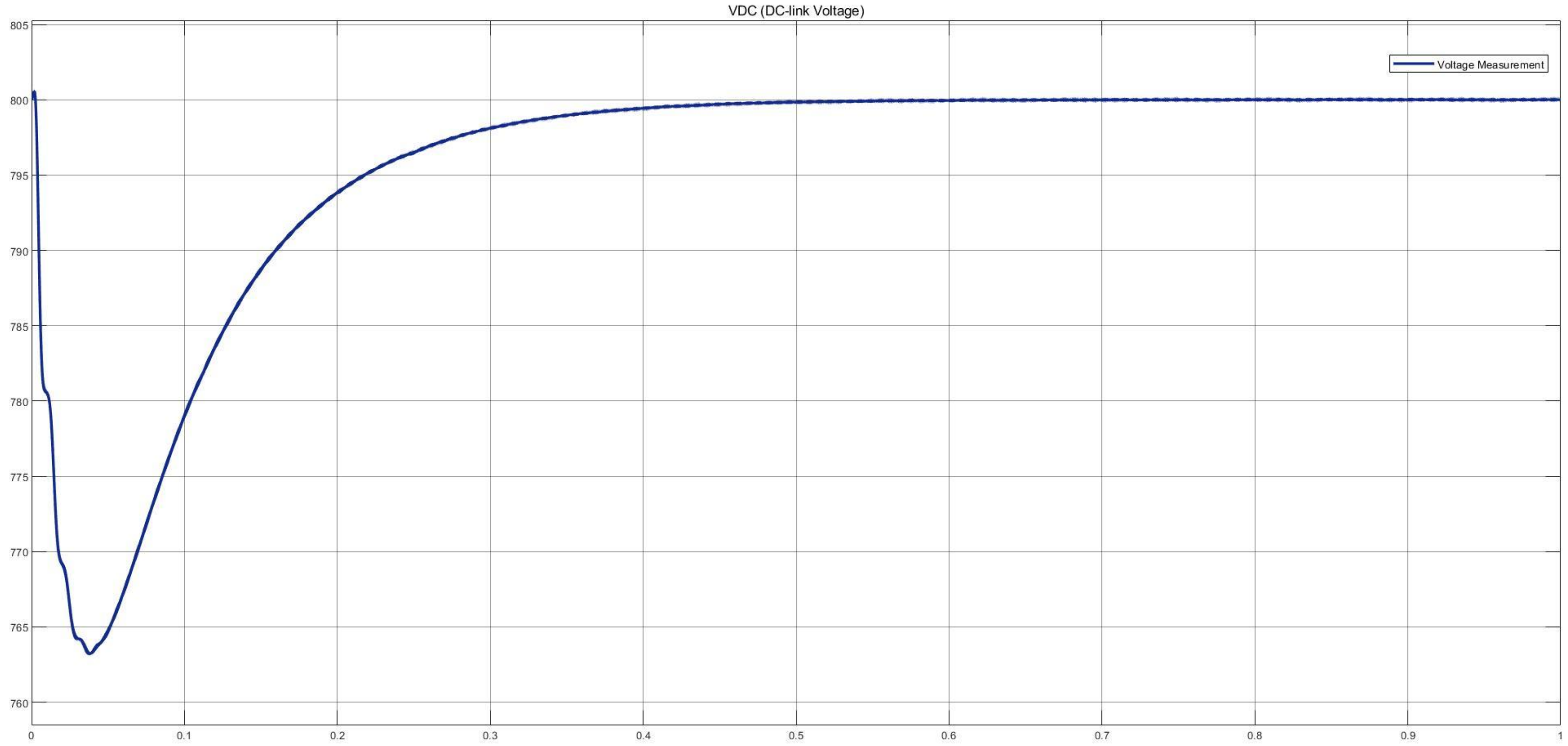


G2V: Grid



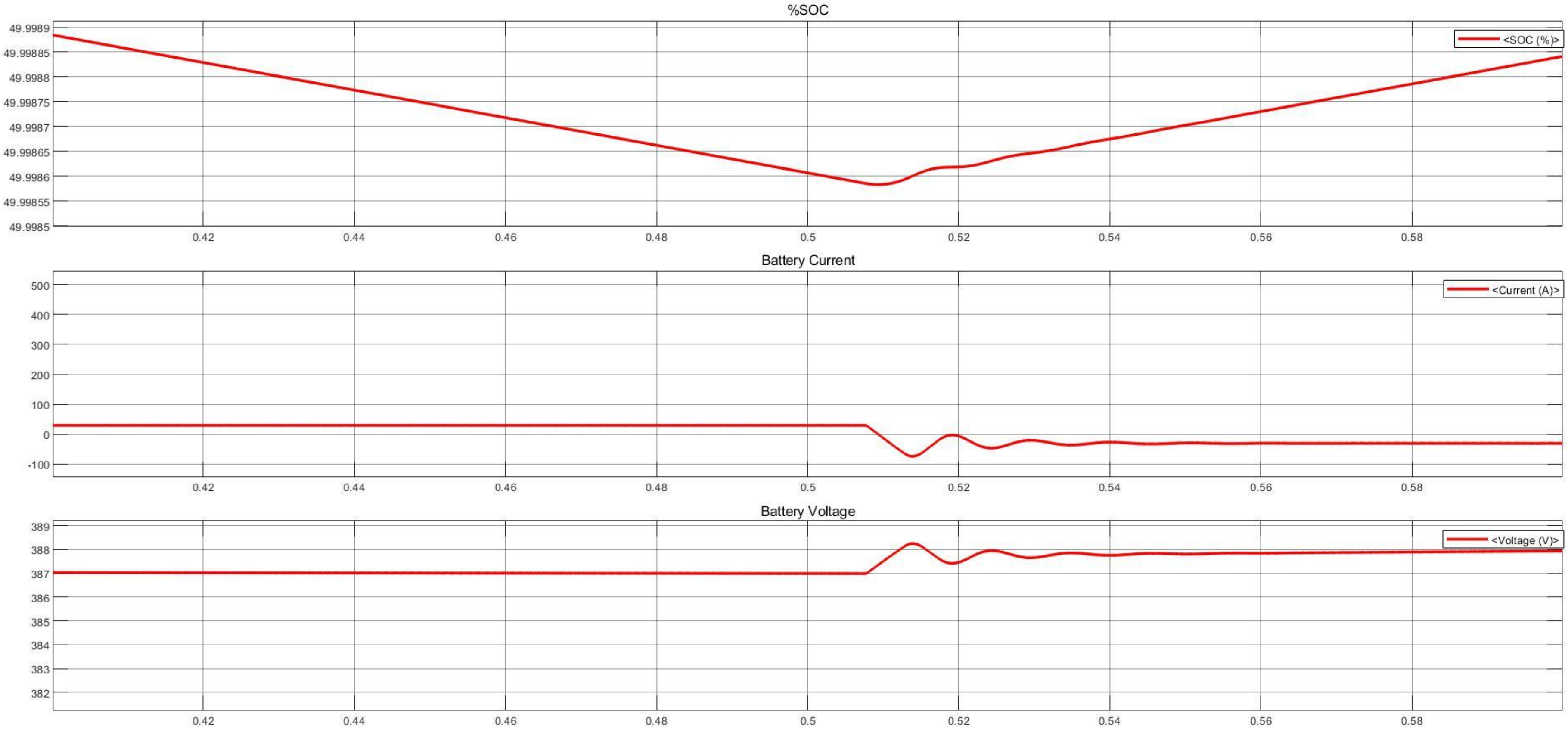
Grid Voltage (R,Y,B)
400
300
200
100
0
-100
-200
-300
0.94
0.95
0.96
0.97
0.98
0.99
1
Grid Current (R,Y,B)
20
15
10
5
0
-5
-10
-15
-20
-25
0.94
0.95
0.96
0.97
0.98
0.99
1

G2V: Vdc

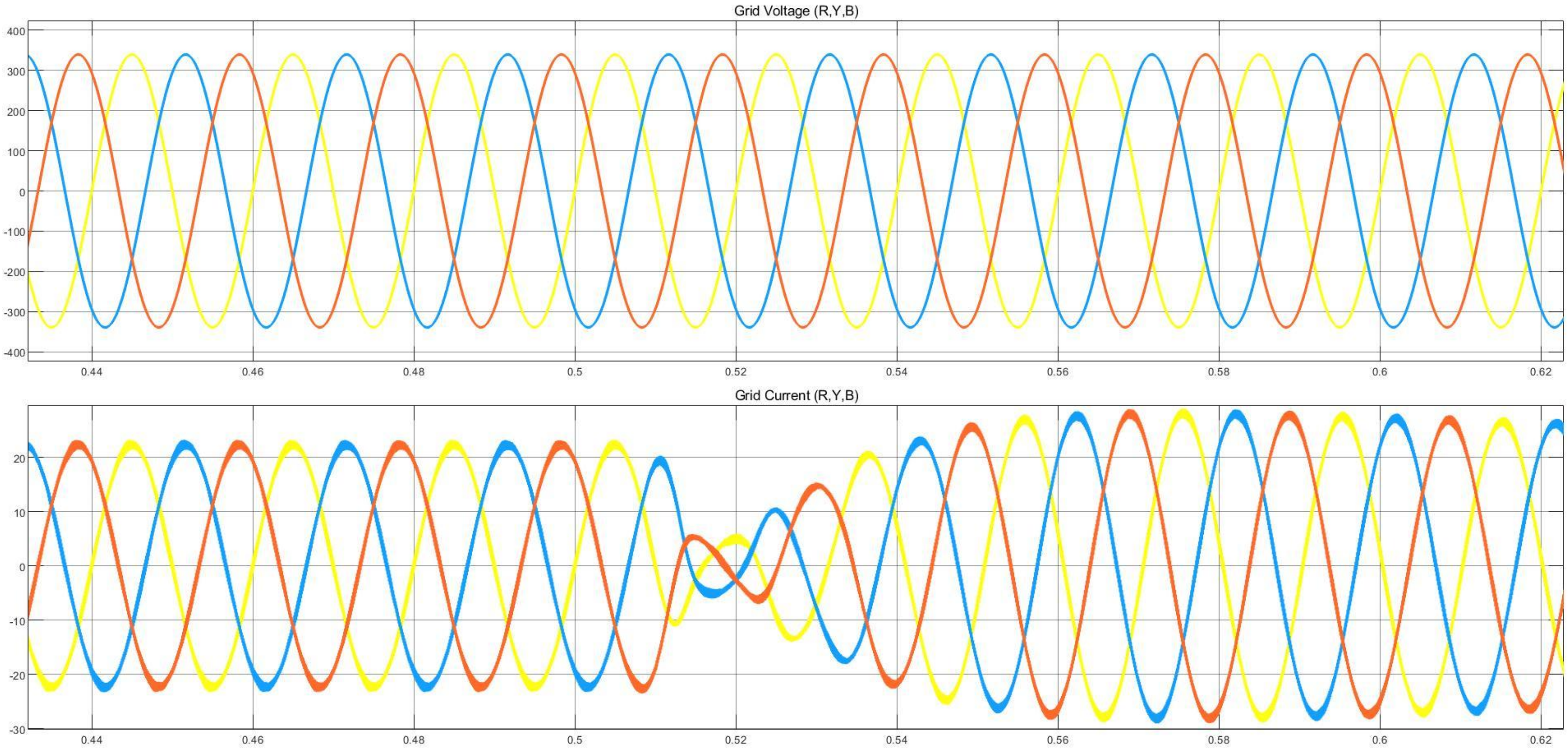


VDC (DC-link Voltage)
Voltage Measurement
805
800
795
790
785
780
775
770
765
760
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

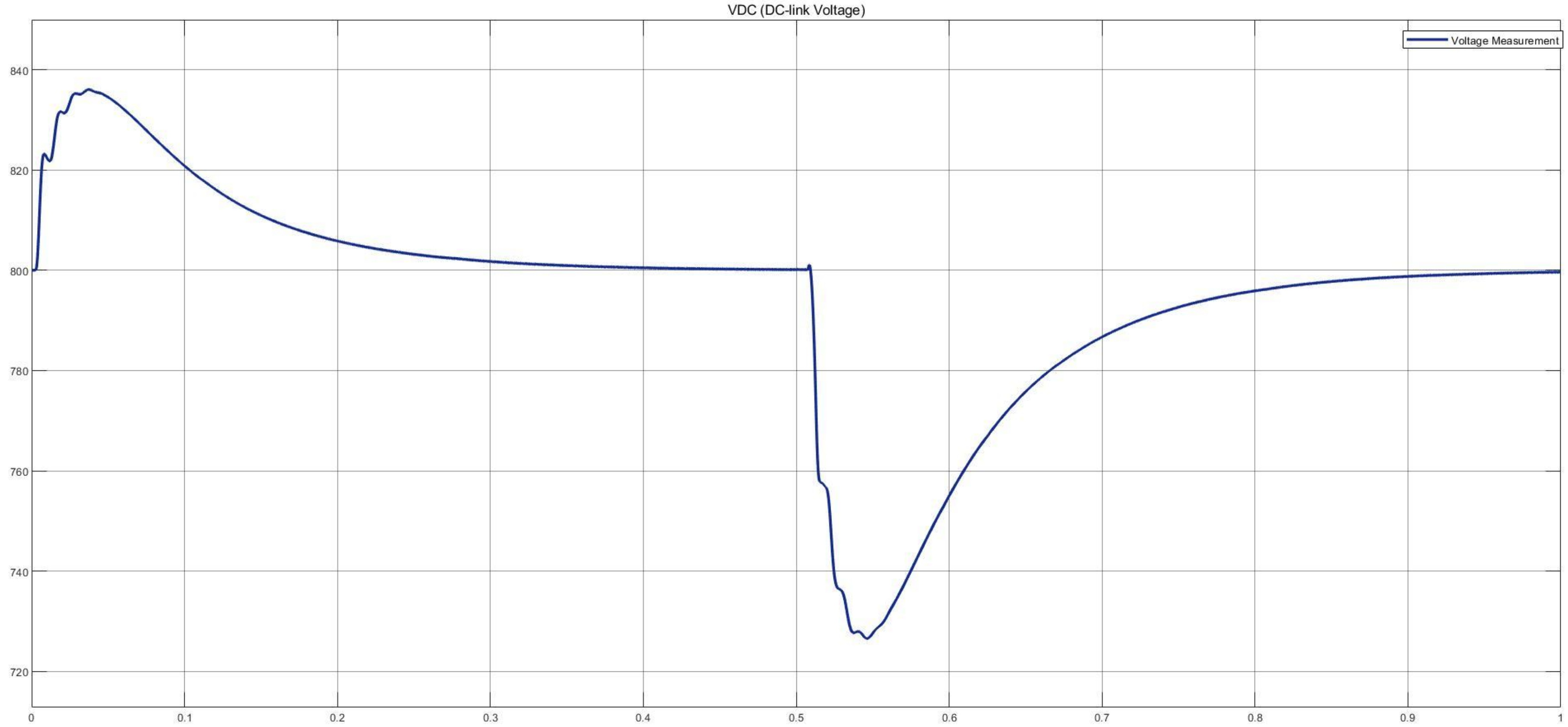
Abrupt change V2G to G2V: Battery Status



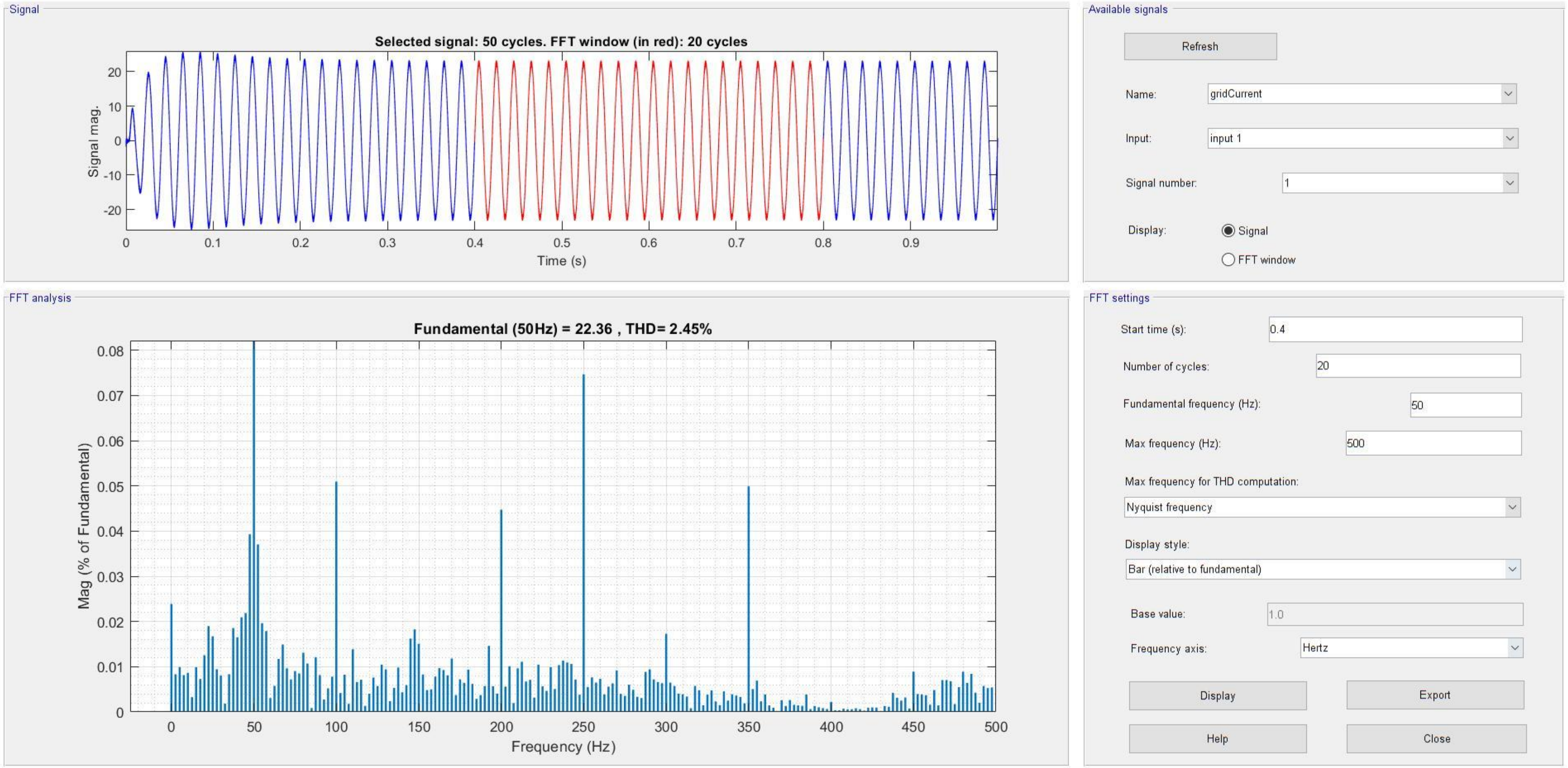
Abrupt change V2G to G2V: Grid



Abrupt change V2G to G2V: Vdc

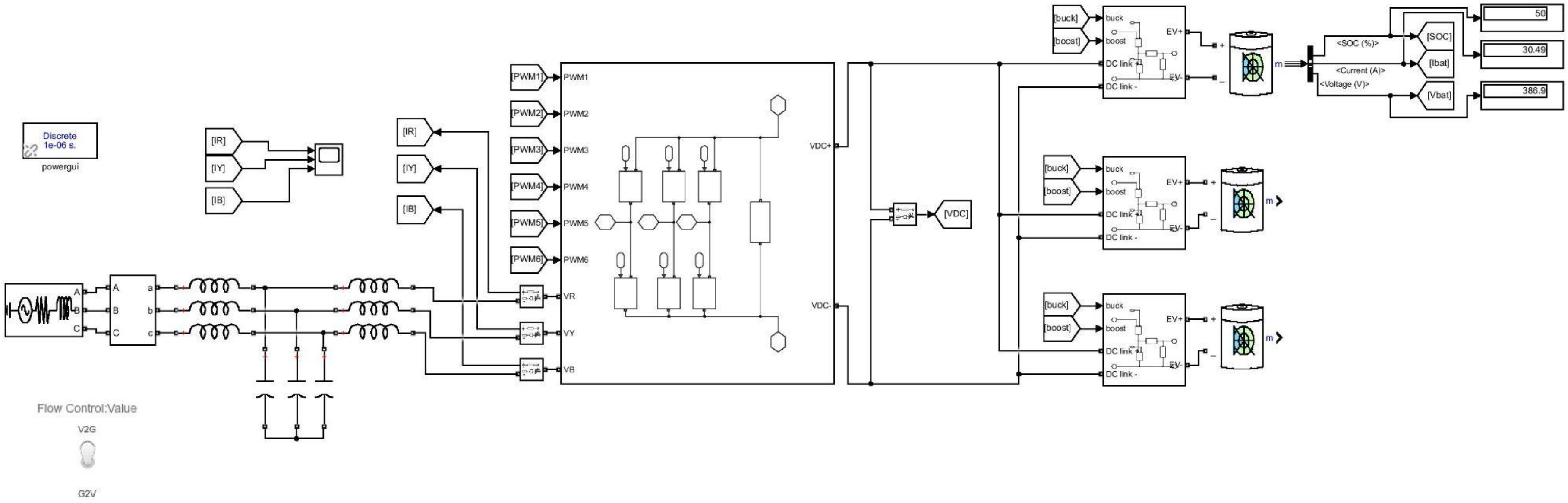


% THD = 2.45%



Signal
Selected signal: 50 cycles. FFT window (in red): 20 cycles
Signal mag.
Time (s)
Available signals
Refresh
Name: gridCurrent
Input: input 1
Signal number: 1
Display: Signal
FFT window
FFT analysis
Fundamental (50Hz) = 22.36 , THD= 2.45%
Mag (% of Fundamental)
Frequency (Hz)
FFT settings
Start time (s): 0.4
Number of cycles: 20
Fundamental frequency (Hz): 50
Max frequency (Hz): 500
Max frequency for THD computation:
Nyquist frequency
Display style:
Bar (relative to fundamental)
Base value: 1.0
Frequency axis: Hertz
Display
Export
Help
Close

9. Parallel operation of batteries

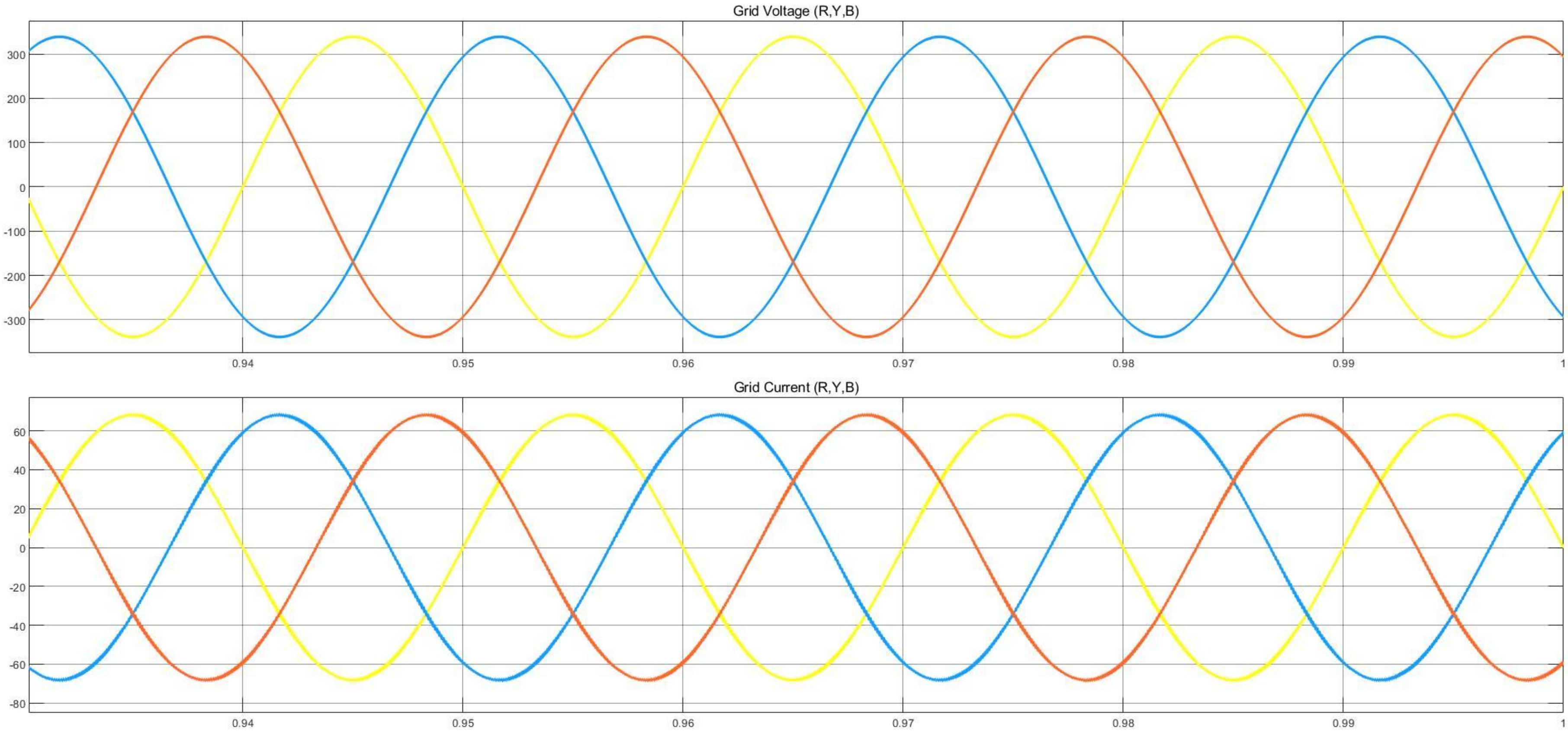


Parameters:

With introduction of DC/DC subsystem in parallel

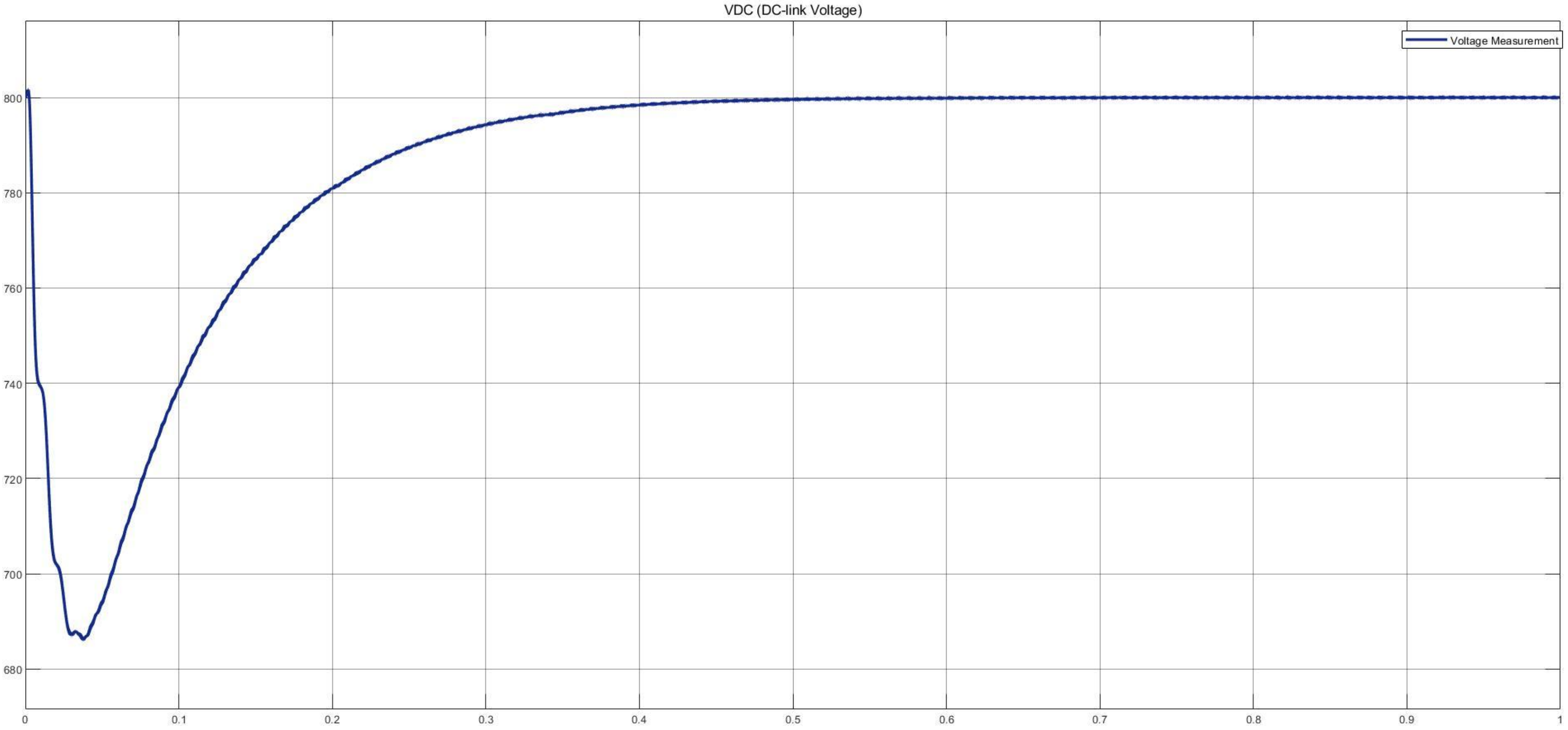
- **Battery:**
  - Nominal Voltage (V) =360
  - Rated Capacity (Ah) = 300
  - Initial SOC = 50%
  - Battery response time (s) = 1e-4
- **Load (RL):**
  - R (ohm) = 0.1e-3
  - L (mH) = 20
- **Load (RC):**
  - R (ohm) = 0.1e-3
  - C (mF) = 0.625
- **3 Phase AC source:**
  - Line Voltage (V_{rms}) = 415
  - Frequency (Hz) = 50
- **DC link**
  - Capacitor = 5600uF
  - Resistor = 1e-3 Ohm
- **Grid Filter**
  - LCL = (5mH, 30uF, 5mH)
- **Switching Freq**
  - IGBT = 10KHz

G2V: Grid



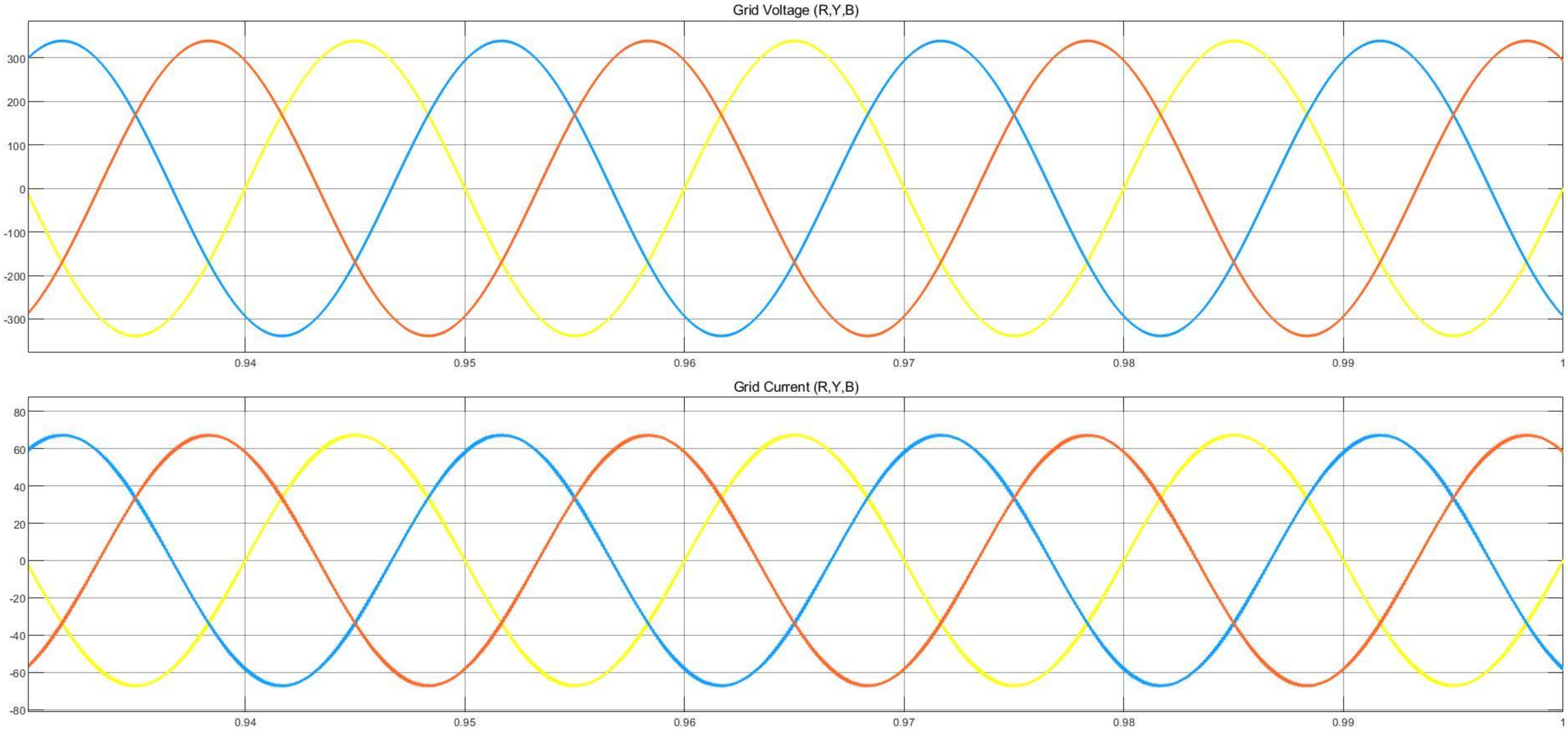
Grid Voltage (R,Y,B)
300
200
100
0
-100
-200
-300
0.94
0.95
0.96
0.97
0.98
0.99
1
Grid Current (R,Y,B)
60
40
20
0
-20
-40
-60
-80
0.94
0.95
0.96
0.97
0.98
0.99
1

G2V: Vdc

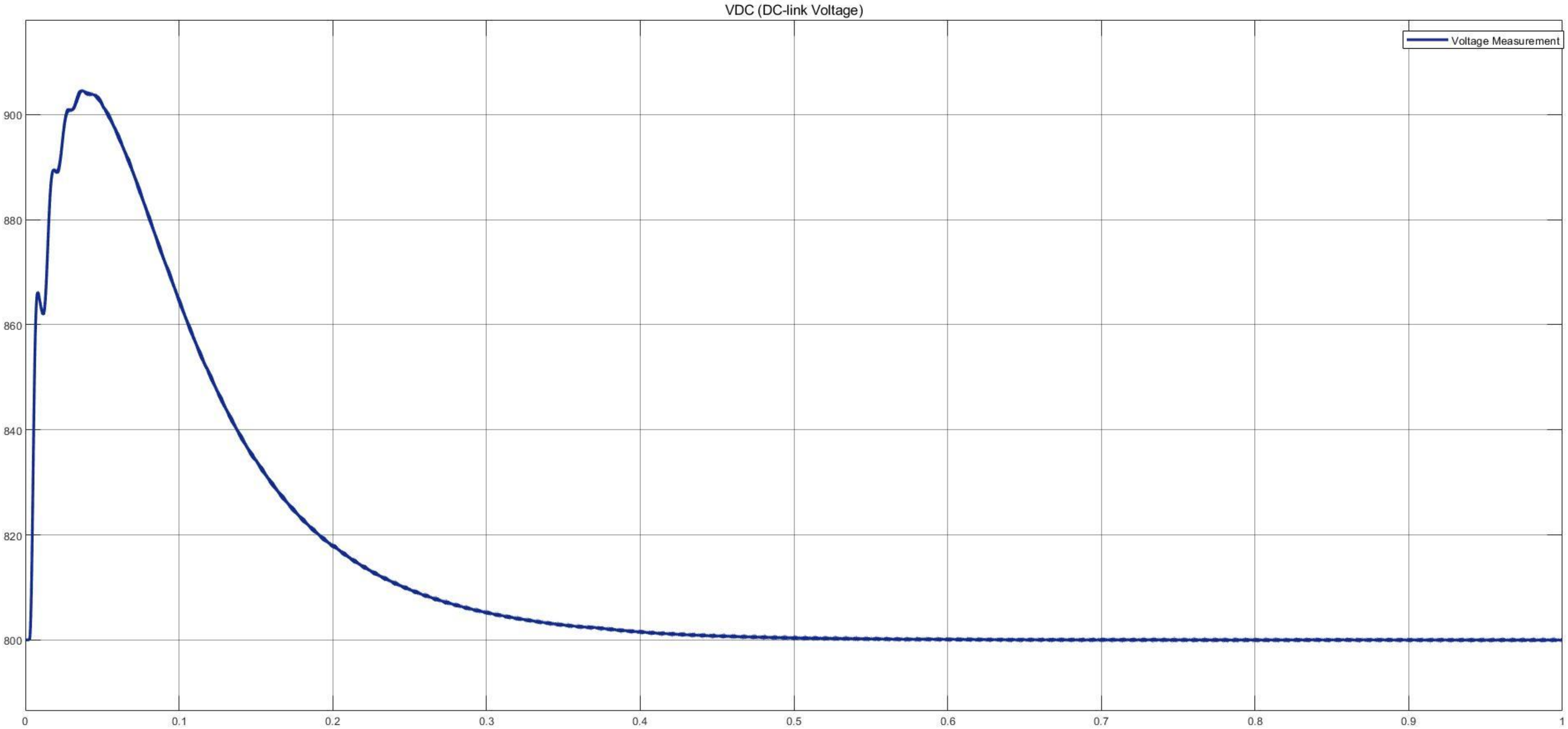


VDC (DC-link Voltage)
Voltage Measurement
800
780
760
740
720
700
680
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

V2G: grd

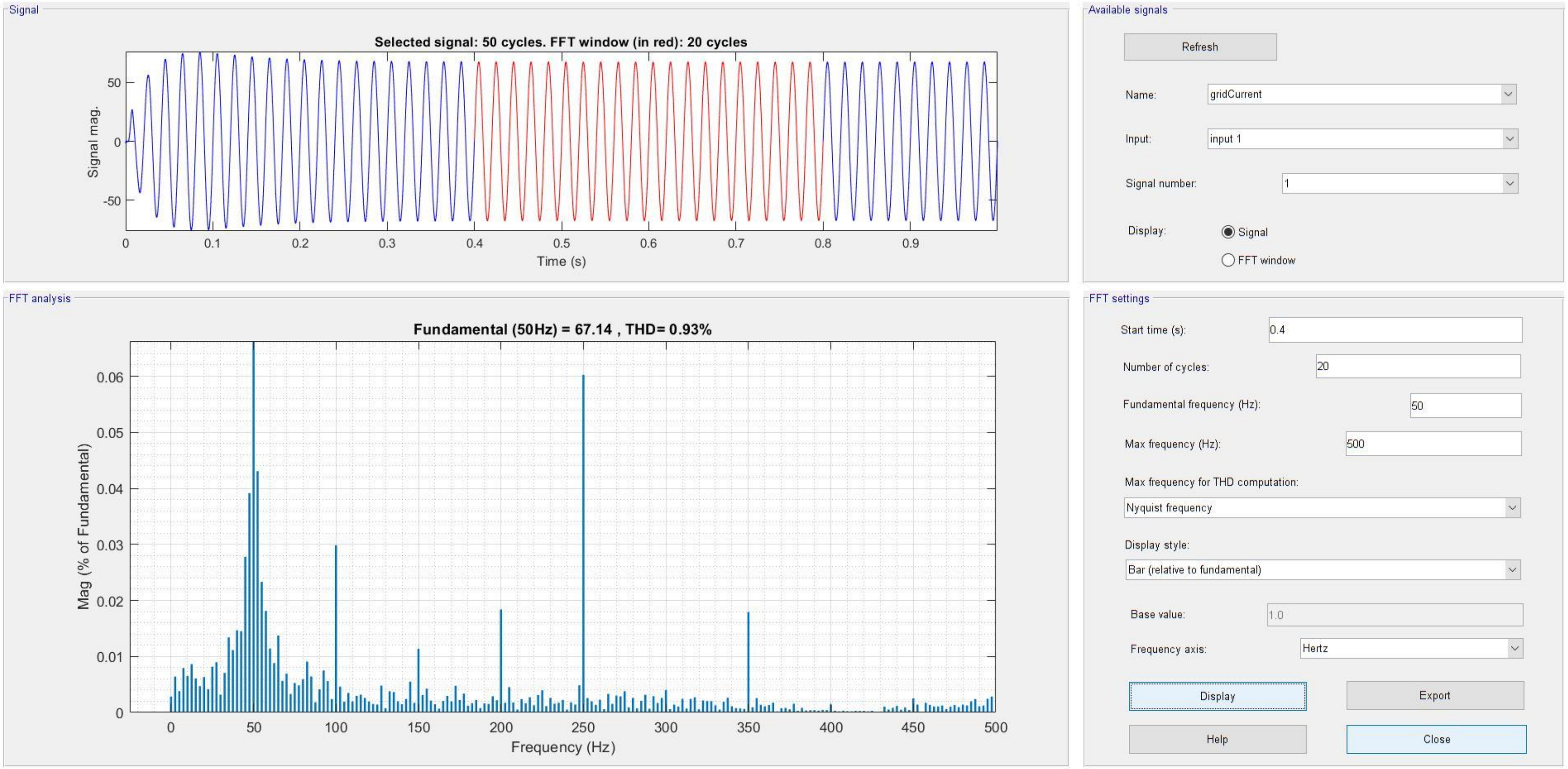

Grid Voltage (R,Y,B)
300
200
100
0
-100
-200
-300
0.94
0.95
0.96
0.97
0.98
0.99
1
Grid Current (R,Y,B)
80
60
40
20
0
-20
-40
-60
-80
0.94
0.95
0.96
0.97
0.98
0.99
1

V2G: Vdc



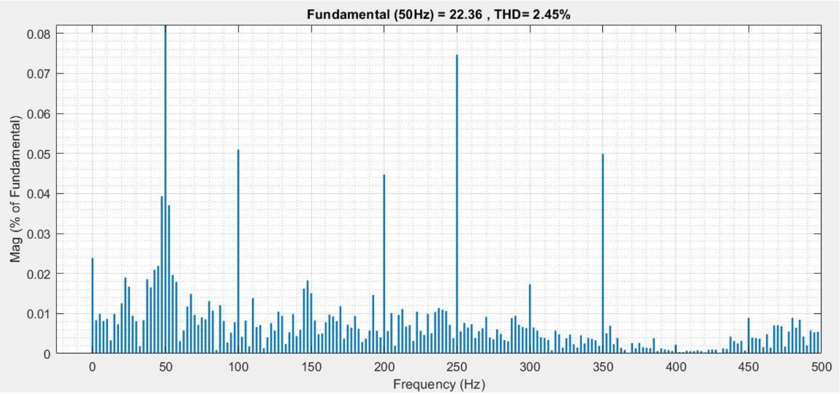
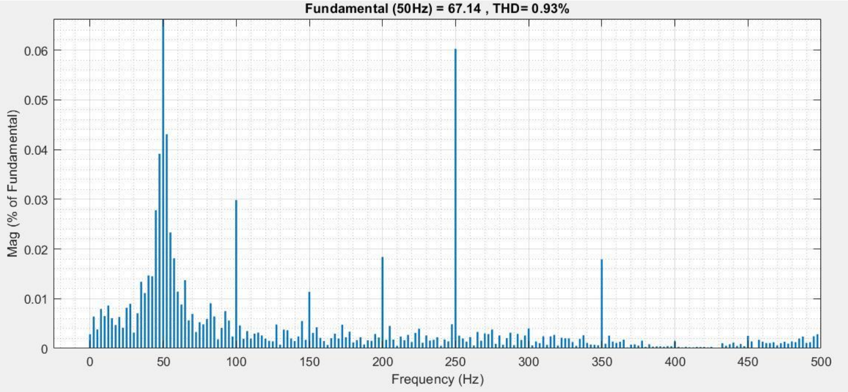
VDC (DC-link Voltage)
Voltage Measurement
900
880
860
840
820
800
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

%THD = 0.93%



Signal
Selected signal: 50 cycles. FFT window (in red): 20 cycles
Signal mag.
50
0
-50
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Time (s)
Available signals
Refresh
Name:
gridCurrent
Input:
input 1
Signal number:
1
Display:
Signal
FFT window
FFT analysis
Fundamental (50Hz) = 67.14 , THD= 0.93%
Mag (% of Fundamental)
0.06
0.05
0.04
0.03
0.02
0.01
0
0
50
100
150
200
250
300
350
400
450
500
Frequency (Hz)
FFT settings
Start time (s):
0.4
Number of cycles:
20
Fundamental frequency (Hz):
50
Max frequency (Hz):
500
Max frequency for THD computation:
Nyquist frequency
Display style:
Bar (relative to fundamental)
Base value:
1.0
Frequency axis:
Hertz
Display
Export
Help
Close

10. %THD comparison

FFT window	Operation	% THD Value
 	Single Battery V2G-G2V operation	THD=**2.45%**
 	Parallel operation of battery in V2G-G2V	THD=**0.93%**

Literature Review

1. Power Decoupling Control for V2G/G2V/PV2G Operation Modes in Single-Phase PV/Battery Hybrid Energy System With Low DC-Link Capacitance

- Flexible three port intelligent system (photovoltaic + EV+ Grid) with decoupled capacitor (DC Ink)
- Single phase three port conversion system to achieve high power density and high reliability
- Inherent double-line frequency ripple power in a single-phase system is actively absorbed by a Li-ion battery pack, with a sinusoidal charging/discharging technique with control strategy

2. Modeling and Performance Evaluation of ANFIS Controller-Based Bidirectional Power Management Scheme in Plug-In Electric Vehicles Integrated With Electric Grid

- An adaptive neuro-fuzzy inference system to tackle t vulnerability to controller gain, accurate mathematical modelling, poor adaptability, sluggish response to a sudden outburst and lengthy interval execution processing
- Strategies to reduce the stress on the grid power side and utilize the unused power properly
- An adaptive neuro-fuzzy inference system (ANFIS) controller to achieve coordinated power exchange between battery storage and the AC electrical grid through different mediators and controllers. A bi-directional power flow between the PEV and AC power grid is accomplished with the help of two ANFIS controllers and a control strategy.

3. Interval Type-2 Fuzzy Logic Controlled Shunt Converter Coupled Novel High-Quality Charging Scheme for Electric Vehicles

- An interval type-2 fuzzy logic controlled shunt converter coupled novel high-quality charging scheme for electric vehicles. This system includes three-phase bidirectional front-end ac–dc pulse width modulation (PWM) converter, backend dc–dc PWM converter and three-phase three-wire distribution static compensator.
- A multistep constant current control technique is proposed for the dc–dc converter to charge and discharge the battery
- Shunt converter coupled novel high-quality charging scheme was designed for EV applications. The shunt converter with effective and efficient control technology was integrated into the conventional charging scheme which reduced the THD of the grid current less than 5%,

4. Second-Order Ripple Minimization in Single-Phase Single-Stage Onboard PEV Charger

- A second-order ripple component compensation technique is proposed by pre compensating the reference current itself. The resultant reference current is periodic in nature, and accordingly, a repetitive controller (RC) is used, for its capability of tracking the periodic signals.
- The performance of the controller has been tested in eight different modes on active–reactive (P-Q) power plane and found that ripple minimization technique successfully reduced second-order ripple component on dc side
- The proposed PEV charger can operate in all four quadrants of active–reactive power plane. This charger controller diminishes the second-order ripple current harmonics component on dc side, and hence, up to 11% may be very helpful in extending the lifetime of battery which having an acceptable ripple of C/10.

5. Integrated G2V/V2G Switched Reluctance Motor Drive With Sensing Only Switch-Bus Current

- Proposed integrated drive, there is no relay to reconfigure and no need to add separate charging/discharging units and circuit components.
- Only one physical current sensor is used to sense the switch bus current to provide all current signals not only for SRM driving, but also grid-to-vehicle/vehicle-to-grid functions at a standstill
- By using one physical current sensor, the motor winding currents and grid current can be reconstructed successfully for the current feedback controls

6. An Extendable Quadratic Bidirectional DC–DC Converter for V2G and G2V Applications

- An extendable quadratic bidirectional dc–dc converter that has an improved voltage transfer ratio (VTR) with the capability of redundancy and modularity for electric vehicle applications. As n modules are embedded, its VTR becomes n times higher for both directions of currents.
- The common electrical ground between the input and output is preserved. This is a simple structure with the lowest rating of semiconductors in the family of quadratic bidirectional converters leading to ease of control ability.
- This converter benefits from the high step-down and high step-up voltage gains, extendibility, high efficiency, and low-rated switches, having a common ground and bidirectional capability.

7. AFF-SOGI-DRC Control of Renewable Energy Based Grid Interactive Charging Station for EV With Power Quality Improvement

- A control of solar photovoltaic (PV) array, and wind energy conversion system based charging station using an adaptive frequency-fixed second-order generalized integrator with dc offset rejection capability (AFF-SOGI-DRC).
- The presented algorithm precisely estimates the fundamental EV current. Moreover, the AFF-SOGI-DRC-based positive sequence extractor helps in generating the sinusoidal in-quadrature unit vectors under distorted and unbalanced grid voltages; therefore, the reference grid currents become harmonic free.
- The controller has ability to extract the fundamental currents from the polluted currents under all operating conditions including unbalanced and distorted voltages. Test results also show that the THDs of grid voltage and current are always maintained less than 5%, even for worst operating conditions.

8. Adaptive Bidirectional Inductive Power and Data Transmission System

- Wireless power transfer i.e loosely coupled inductive power transfer (LCIPT) considers the change of mutual inductance when two induction coils are misaligned.
- The phase shift pulse width modulation technique is proposed for simultaneous data transmission enabling binary quadrature amplitude modulation for digital signal transmission. Fast over current protection is incorporated for power transfer safety when current overload happens
- LCIPT system for electric vehicles with its architecture supporting simultaneous power and data transmission in both of the primary and secondary sides while accounting for mutual inductance changes with no extra RF links needed for data communication

9. Impact of V2G Communication on Grid Node Voltage at Charging Station in a Smart Grid Scenario

- Impact of realistic communication systems on charging stations at multiple nodes of the sub feeder in an electricity grid distribution system. A vehicle to grid (V2G) system is model comprising of the electricity grid, aggregators, controllers, charging station, electric vehicles, and communication channels.
- Fuzzy logic controllers are at two levels; one at the distribution level and the other at the charging station level.Two types of communication channels are considered between the entities of the V2G network with charging stations at multiple nodes of the electricity grid
- The power exchanged between EVs and multiple charging stations is determined using multiple FLCs and aggregators at the distribution level and CS level. Communication channels modeled between entities of the V2G system are analyzed in terms of Bit error rate (BER), timeout required to send packets in multiple transmissions, and number of EVs.

10. Dual-Input Non-isolated DC-DC Converter with Vehicle to Grid Feature

- Non-isolated dual-input single output DC-DC converter (DISOC) is proposed. The DISOC structure can be configured to perform six types of operation based on the status of power availability with PV, battery and also the running status of the EV.
- Simultaneous power transfer from both the input sources, charging the battery from solar PV, V2G and G2V operations are the key features of the proposed converter.
- Six operating modes, less component, more output voltage and improved efficiency are the key features of the proposed DISOC. A dedicated controller, real-time application of DISOC using solar PV and battery, MPPT of solar PV, motor and its control and power management strategy are offered as future scopes in this research.

11. A Wide Range High Voltage Gain Bidirectional DC-DC Converter for V2G and G2V Hybrid EV Charger

- The converter preserves the common electrical ground between input and output terminals, and presents a low voltage stress of switches, high utilization factor and high efficiency.
- The converter uses a dead-beat current controller in the dc-dc and dc-ac stages which has a smooth, accurate and fast response.
- This converter benefits from high step-down and high step-up voltage gains, high efficiency, low rating of switches, having common ground and bidirectional capability. The proposed converter has utilized a dead-beat controller which ensures smooth and accurate current control for both directions of operation.

12. Power Enhancement With Grid Stabilization of Renewable Energy-Based Generation System Using UPQC-FLC-EVA Technique

- The Fuzzy Logic Controller (FLC) decides the economic utilization of power during peak load and off-peak load. The reduced power quality at the load side is observed as a result of varying loads in the random fashion and this issue is sorted out by using Unified Power Quality Conditioner (UPQC) in this proposed study.
- FLC-based maximum power point tracking (MPPT) technique and artificial neural network (ANN)-based technique is utilized for the development of the MPPT algorithm.
- A key observation from the results and analysis indicates that the power output from FLC-based MPPT is better than that of ANN-based MPPT. Thus, the proper and economical utilization of power is achieved with the help of FLC and UPQC

13. Bidirectional Charging in V2G Systems: An In-Cell Variation Analysis of Vehicle Batteries

- Battery pack in EV may develop incell dynamic variations over time: first, additional charging and discharging cycles to power grid; second, external shocks; and third, long exposures to high temperatures. A particular source of these variations is due to faulty sensors.
- A prediction based scheme to monitor the health of variation induced sensors is proposed. First, a propagation model is developed to predict the in-cell variations of a battery pack by calculating the covariance using a median-based expectation
- A hypothesis model is developed to detect and isolate each variation. This is obtained by deriving a conditional probability-based density function for the measurements.

14. A Multifunctional Single-Phase EV On-Board Charger With a New V2V Charging Assistance Capability

- The designed EV charger can support the proposed V2V function with rated power and without the need for an additional portable charger
- It can also provide conventional functions of V2G, G2V, STATCOM and active power filter (APF) (i.e. reactive power support, and harmonics reduction).
- V2V operation meets the standard SAE J1772 and can be accomplished with the maximum power ratio of the EV charger. The V2V function enables an EV to be charged from another EV during an emergency when there is no access to a charging station

15. A Hierarchical V2G/G2V Energy Management System for Electric-Drive-Reconstructed Onboard Converter

- A hierarchical V2G/G2V energy management system and the corresponding hierarchical control strategy with the proposed electric-drive-reconstructed onboard converter (EDROC).
- The proposed control strategy achieves the reasonable distribution of energy between the PEVs under a hierarchical control structure.
- V2G/G2V system which controlled under the proposed control strategy avoids overcharging, and reduces the dispersion of PEV SOC.

16. A Novel Electric Vehicles Charging/Discharging Management Protocol Based on Queuing Model

- EV load management technique based on EV charging and EV discharging coordination. It proposed a peak load management model (PLM) used to schedule EVs for charging or discharging service according to the power demand with the timing and location where each EV need to be served
- Propose an Electric Vehicle Supply Equipment (EVSE) selection model to guide EVs to the supply station. A mathematical formalism for handling requests for EV charging/discharging at EVSE based on queuing theory. Those models are evaluated while considering the mobility of vehicles in an urban scenario and time-of-use-pricing (TOUP).
- A peak load management (PLM) which is used to schedule EVs for charging or discharging service according to the power demand with the timing and location where EV needs to be served. This algorithm uses efficiently unused stored energy in PEV battery to supply the grid to fulfill power demand, especially in peak times during the day.

17. Design Methodology of a Three-Phase Four-Wire EV Charger Operated at the Autonomous Mode

- An output-voltage control with harmonic compensation plus virtual impedance term is proposed to achieve high power quality and necessary damping, respectively.
- It provided a design methodology of controllers in a three-phase four-wire VSI. A neutral leg with split dc-link capacitors provides a stable neutral point, even with extremely unbalanced loads
- Due to the stabilized neutral point, three-phase legs could be controlled independently

18. A Drivetrain Integrated DC Fast Charger With Buck and Boost Functionality and Simultaneous Drive/Charge Capability

- An onboard integrated dc charger, leveraging the traction inverter, and motor winding inductance to ensure the minimum incremental mass
- It also proposes simultaneous driving and charging, especially useful for semi trailer trucks applications, significantly increasing operational range
- This functionality is achieved without the addition of passive components, thus with the minimum weight penalty, as the motor windings are used for power filtering. The traction inverter is also leveraged, minimizing the number of switches added from a regular VSC inverter drive train

19. Dynamic Economic/Emission Dispatch Including PEVs for Peak Shaving and Valley Filling

- Dynamic Economic/Emission Dispatch (DEED) including PEVs for peak shaving and valley filling is proposed, and furthermore, the effect caused by different vehicle-to-grid (V2G) and grid-to-vehicle (G2V) loads on DEED is analyzed.
- Optimization model of the problem is constructed including several practical constraints, such as power flow constraints and ramp rate limits. The battery degradation cost is also included, which reshapes the objective function of DEED
- The analysis of the effect on fuel cost and emission caused by different V2G power shows that the proposed strategy can effectively reduce the emission and cut down the investment in peak load plants.

20. A Highly Efficient Multifunctional Power Electronic Interface for PEV Hybrid Energy Management Systems

- An integrated multifunctional PEI is proposed to effectively instead of deploying multiple independent dc/dc converters and it suffers from bulky size and high hardware cost.
- It integrates the CLLC resonant topology with the bidirectional interleaved buck/boost topology, in which the former is utilized in the G2V and V2G modes, while the latter is in charge of the driving mode
- A synchronous rectification (SR) technique is developed to actively control the MOSFETs in CLLC rectification stage. Soft switching and SR techniques work in synergy to ensure a high conversion efficiency.

21. On an Electric Scooter With G2V/V2H/V2G and Energy Harvesting Functions

- The bilateral dc/dc converter-fed scooter dc motor drive is established. In an idle case, the motor drive can be arranged to perform the V2H and V2G discharging operations. A front-end dc/dc converter is developed using the motor-drive-embedded components to establish the boosted and well-regulated dc-link voltage from battery.
- An H-bridge single-phase inverter is established to yield the ac 110-V/60-Hz source for home appliances or emergency power use. Good output sine-wave voltage waveforms are yielded by the designed robust and proportional plus-resonant controllers
- A bidirectional dc/dc converter fed is applied to power the scooter PM dc motor to preserve good driving and regenerative braking control performances. Moreover, the human interface interlock mechanism is properly arranged to have smooth operations during mode transition

22. Modeling and Assessment Analysis of Various Compensation Topologies in Bidirectional IWPT System for EV Applications

- The bidirectional wireless power interface is a better choice of application, since it provides automatic, reliable, and safe operation.
- Bidirectional inductive wireless power transfer system (BIWPTS) in EV implementations. The analysis is presented for the three main compensation configurations: LC series, LC-parallel, and LCL-topology.
- The results demonstrate the ability of the proposed models to provide accurate estimation for BIWPTS performance under various operating and control conditions. Also, the evaluation analysis shows that LCL-topology is more appropriate for the bidirectional operation due to the simple design and control requirements, and being less sensitive to the misalignments.

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Thank You

Suggestions by Panel