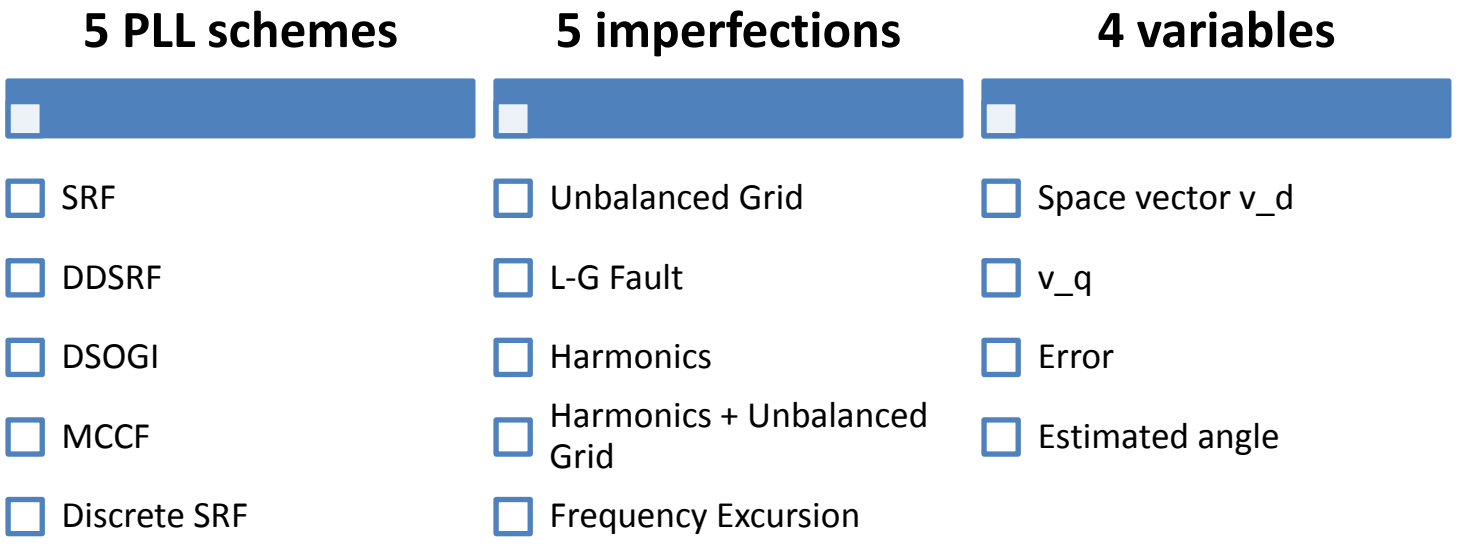
- Recap
  - SRF, DDSRF, DSOGI, MCCF, Discrete SRF
    - **SRF**: conventional PLL – tracks changes in frequency and phase
    - **DDSRF**: attacks the issue of unbalanced grid
    - **DSOGI**, **MCCF**: deal with harmonics and unbalanced grid
  - The above algorithms were studied from literature, mathematically analyzed and implemented using MATLAB Simulink

- Algorithms
  - SRF – Stationary to synchronous reference frame
    - » Loop Filter, Integrator, Closed loop system
  - DDSRF – Decoupling network is the major improvement
    - » Enables tracking in unbalanced situation through decoupling of positive and negative sequence voltages
  - DSOGI – Second order generalized integrator type filter
    - » Filters out the fundamental component in the stationary reference frame
  - MCCF – Multiple Complex Coefficient Filters
    - » Requires two modules for eliminating every harmonic component
  - Discrete SRF – Discretized version of the SRF PLL
    - » Input is sampled, transfer functions in z-domain

- Formulating a **common convention**
  - All existing PLLs are modifications of the conventional SRF PLL
  - Different conventions are followed in literature
  - Single platform between different schemes requires a common convention

- Simulation of each scheme required an in-depth understanding since mathematical models had to be re-designed to suit to our convention
- Each scheme was modeled and tested individually and these models were clubbed into a single self-consistent model for comparison
- Complexity involved – more than **600 comparisons**!!



- Development of an **applet** (learning tool)
  - **Parts**
    - Initialization program
    - Simulink models
    - Intuitive program to plot
  - **Demo**
  - **Importance** of the applet
    - Excellent tool for learning – How?
    - Easy to use
    - To find out which scheme tackles a particular issue better
    - Additions of other schemes (if required) can be easily done

- **Future work**
  - Design optimization aimed at achieving a faster dynamic performance
  - Verification of results through practical setup

Thank you

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Synchronous Reference Frame PLL (SRF)

Situations:

1. Frequency Excursion
2. L-G Fault
3. Harmonics
4. Unbalanced Grid
5. Harmonics + Unbalanced Grid

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Other PLL scheme comparisons

Situations:

1. Frequency Excursion
2. L-G Fault
3. Harmonics
4. Unbalanced Grid
5. Harmonics + Unbalanced Grid

Discrete PLL

Situations:

1. Frequency Excursion
2. L-G Fault
3. Harmonics
4. Unbalanced Grid
5. Harmonics + Unbalanced Grid

SRF PLL on L-G Fault

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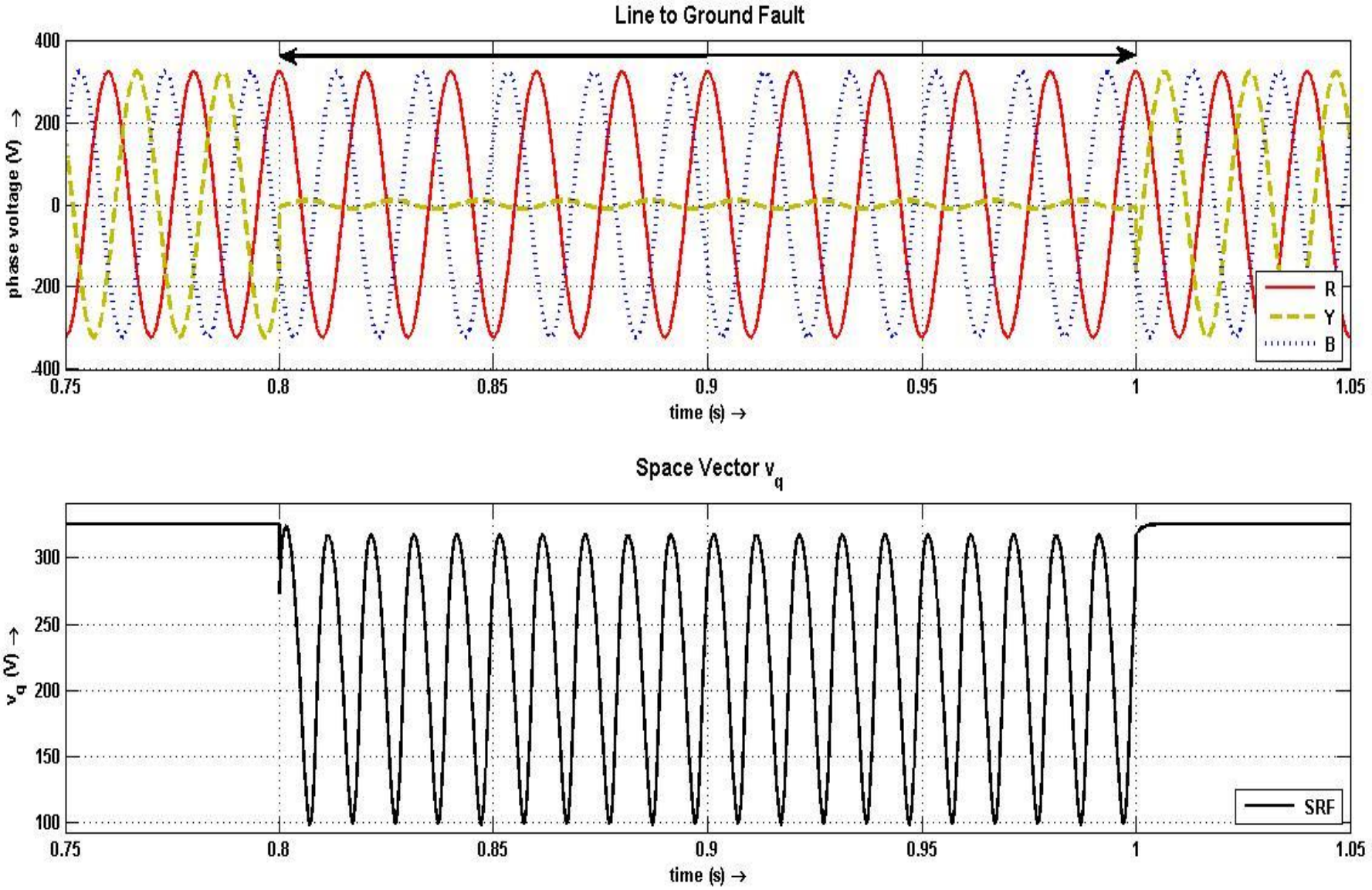

SRF PLL on Frequency Excursion

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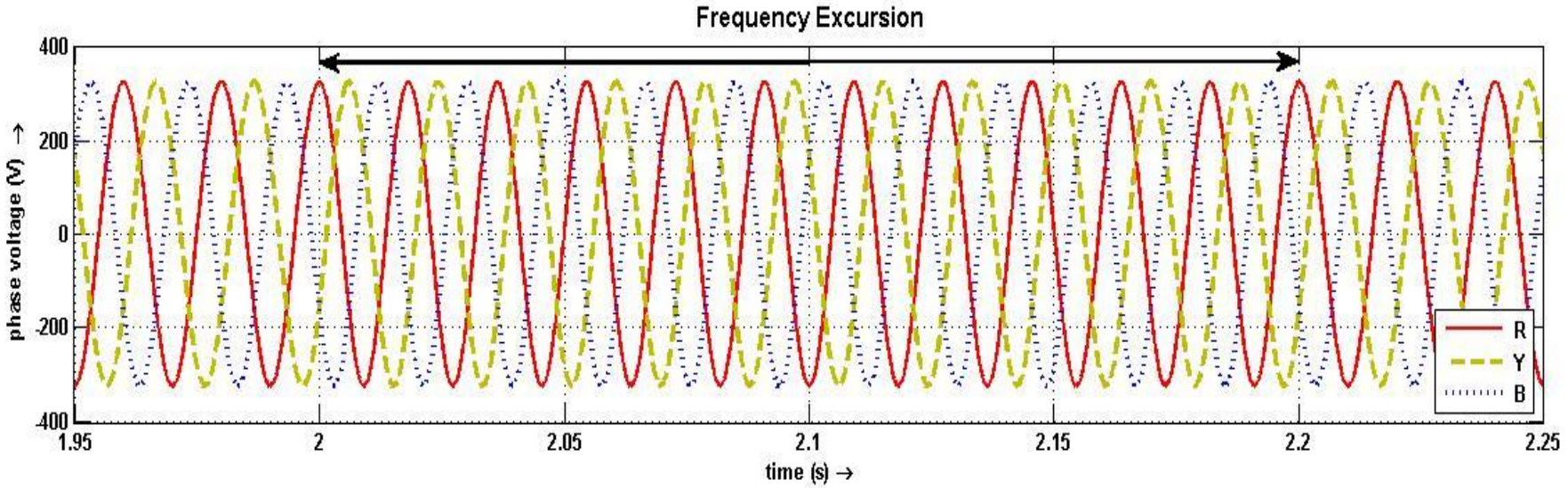

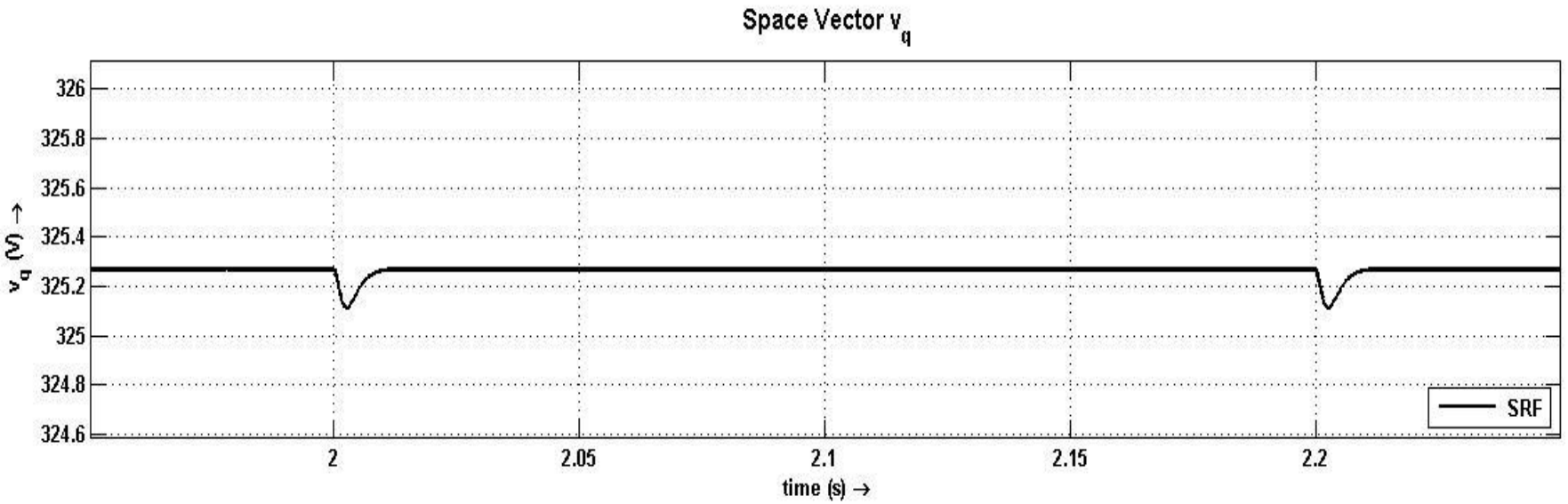

SRF PLL on Harmonics

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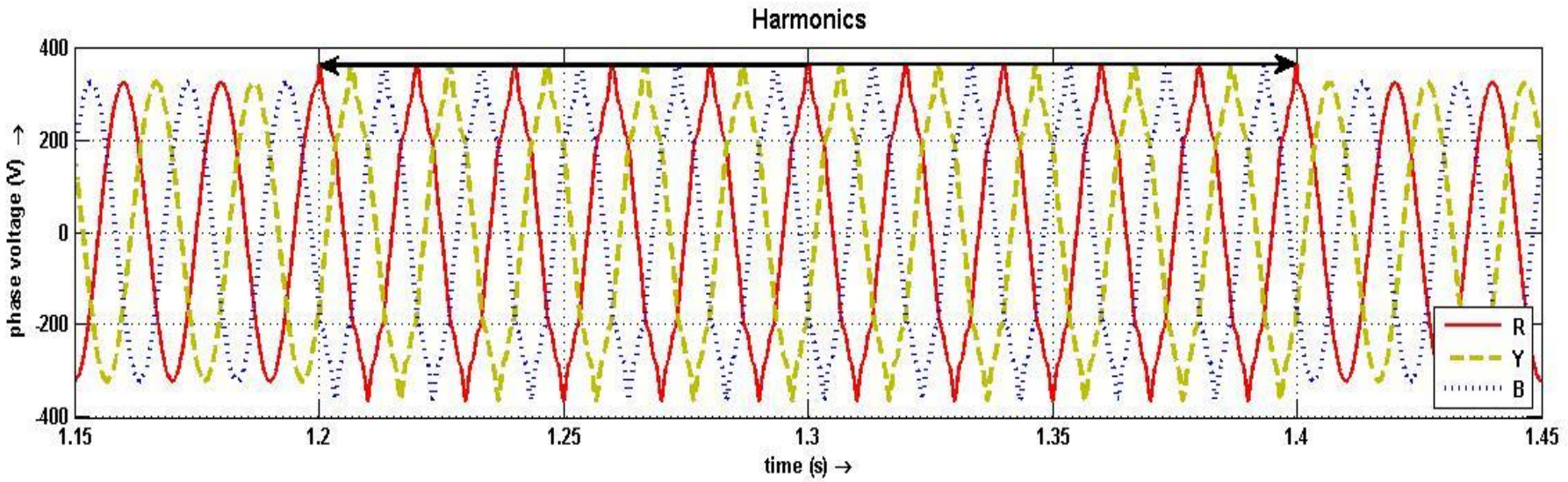

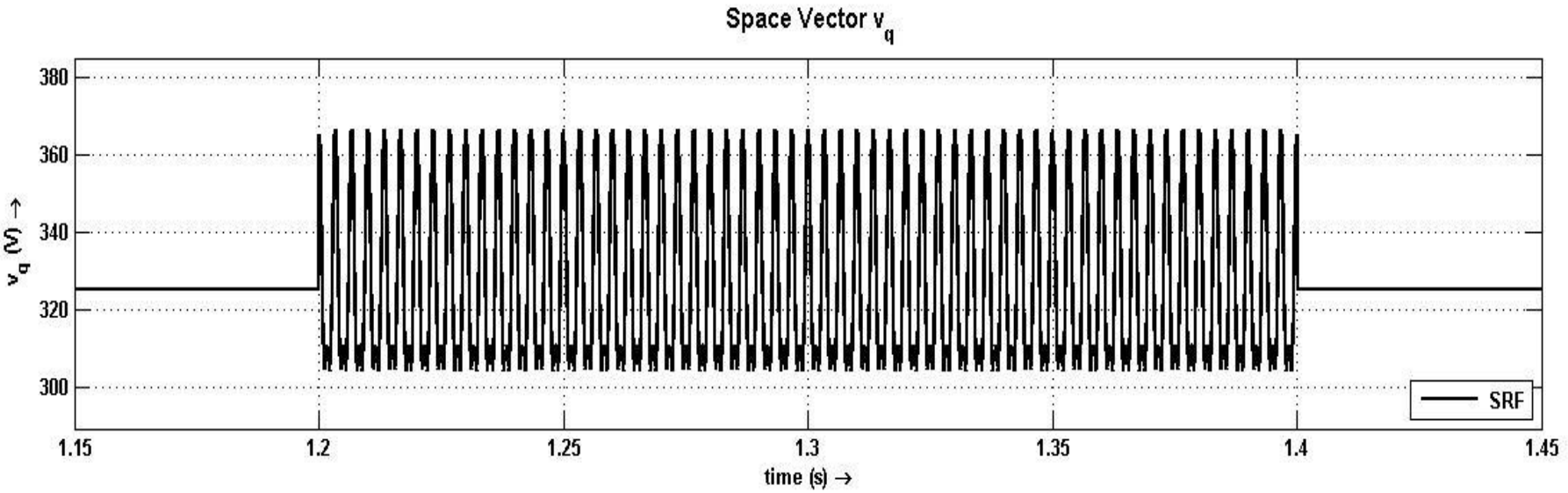

SRF PLL on Unbalanced Grid

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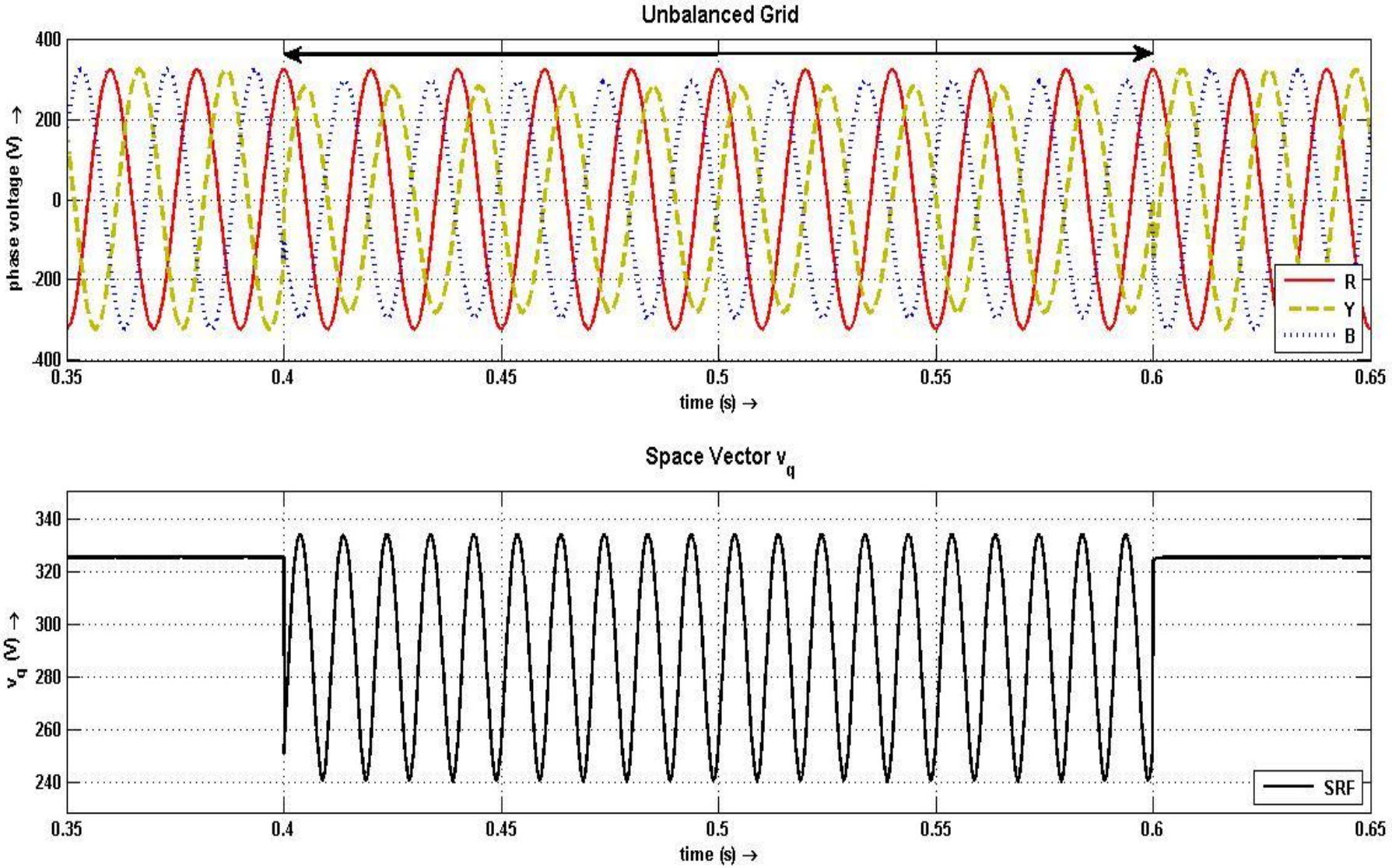

SRF PLL on Harmonics + Unbalanced Grid

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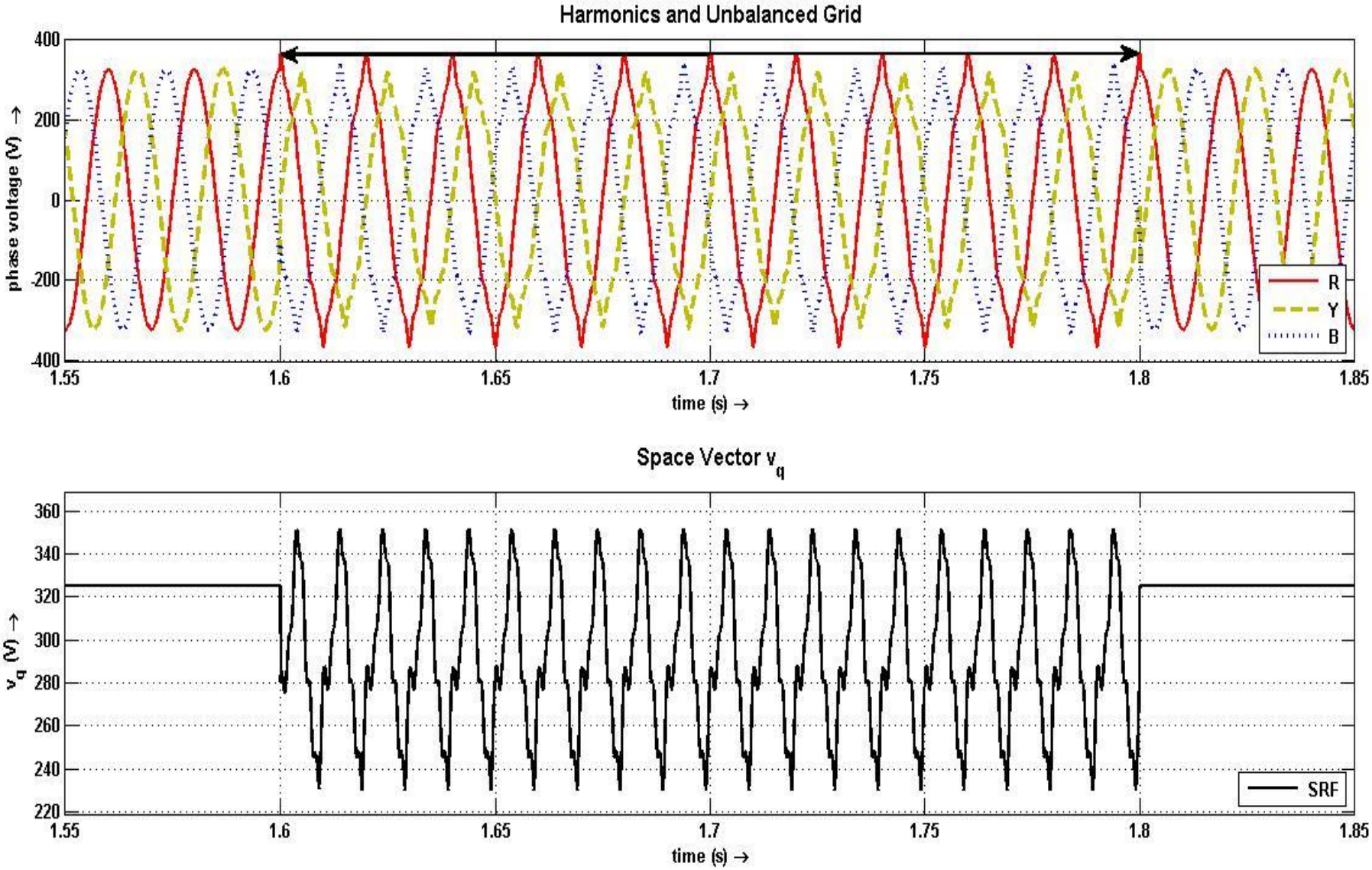

DDSRF, DSOGI, MCCF on L-G Fault

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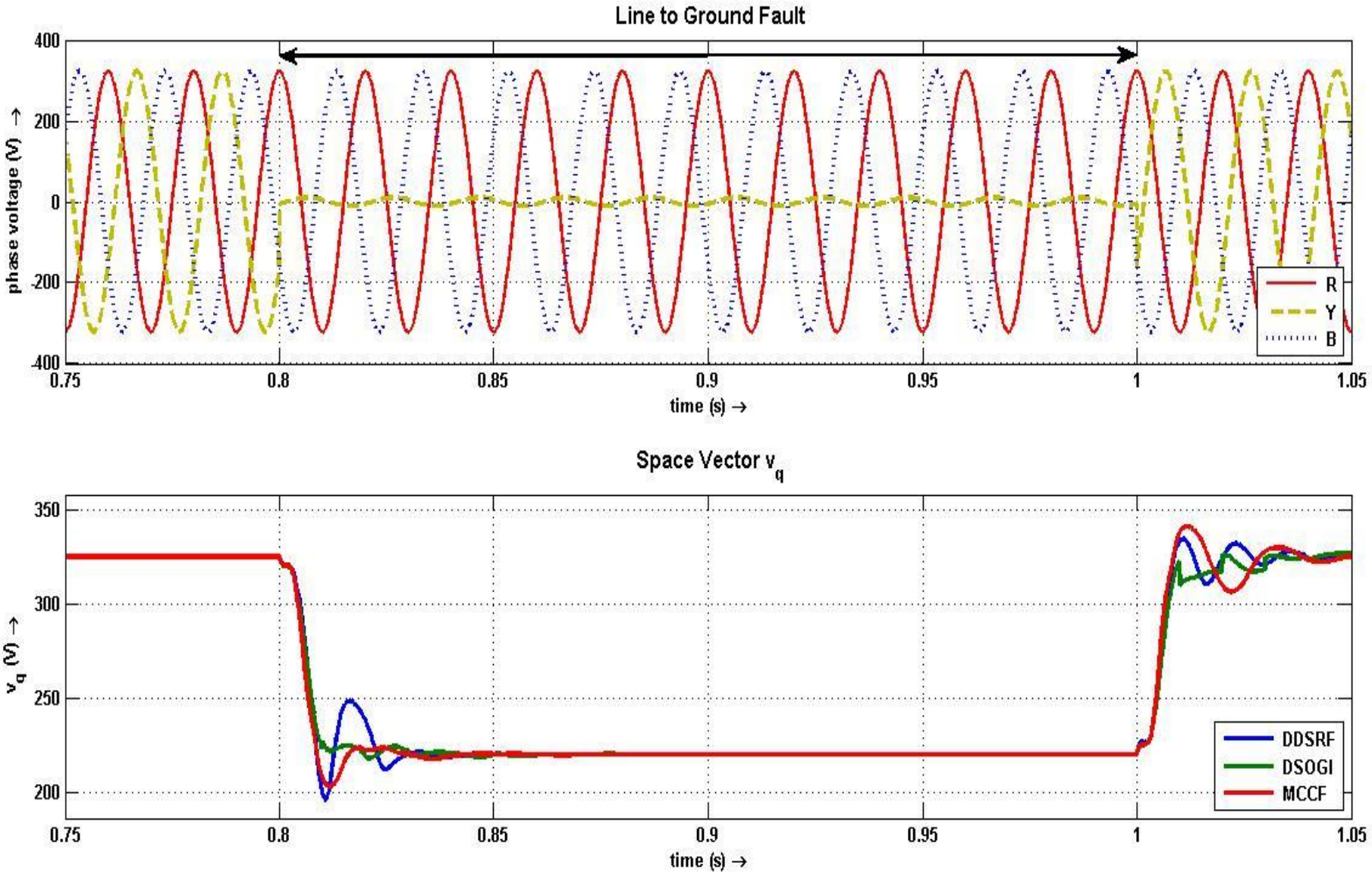

DDSRF, DSOGI, MCCF on Unbalanced Grid

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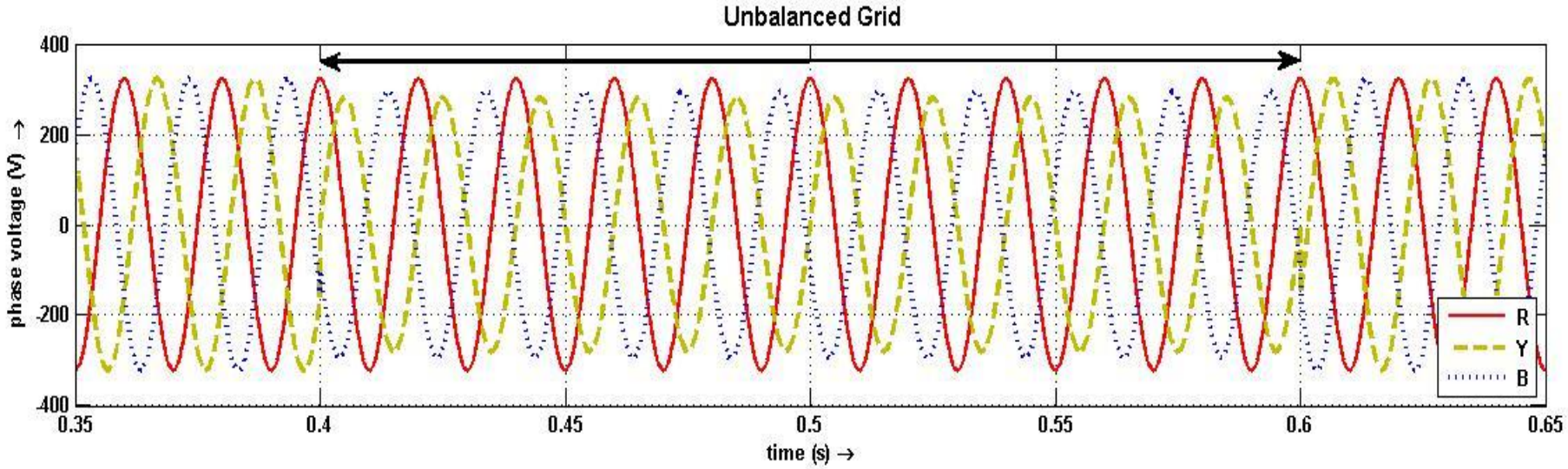

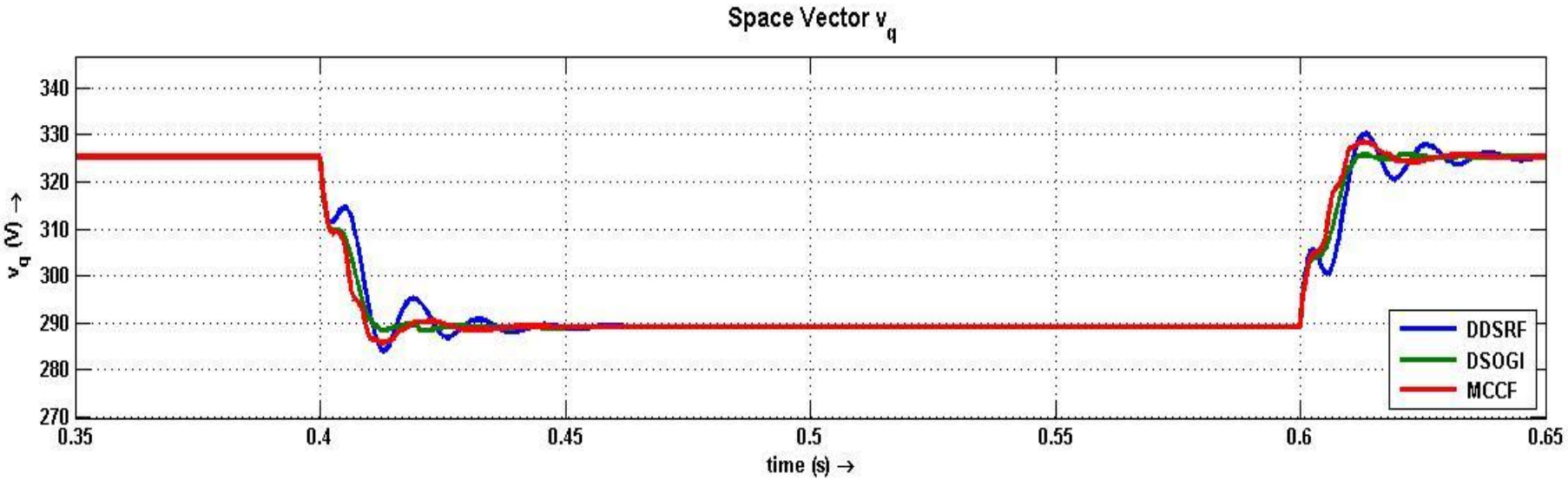

DDSRF, DSOGI, MCCF on Harmonics

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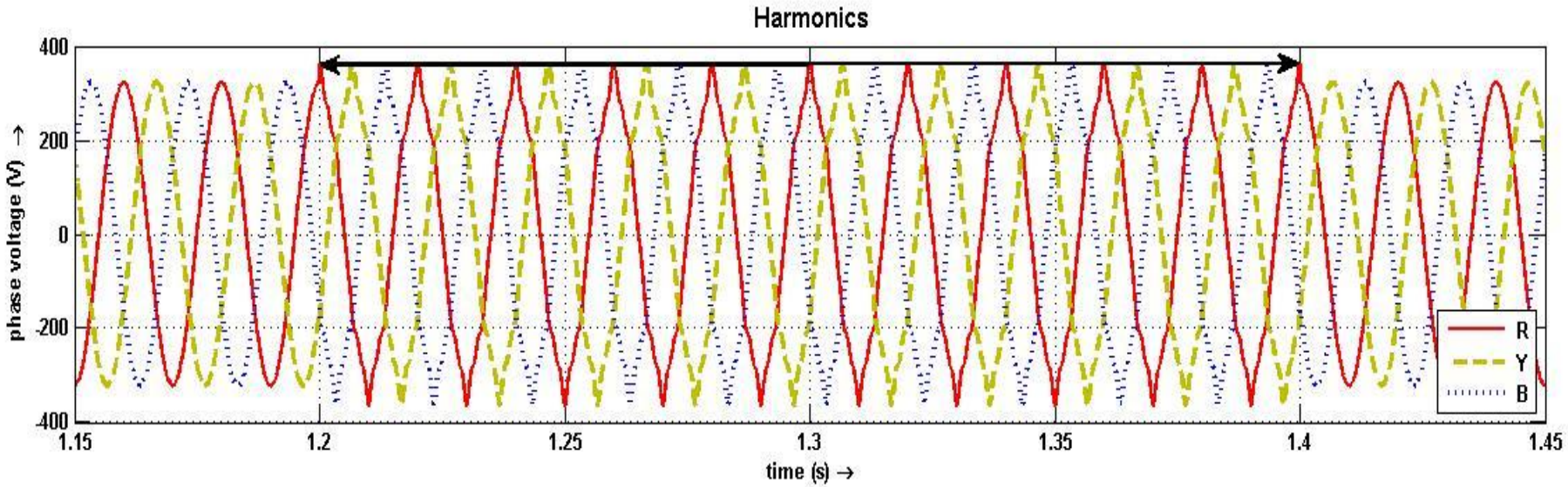

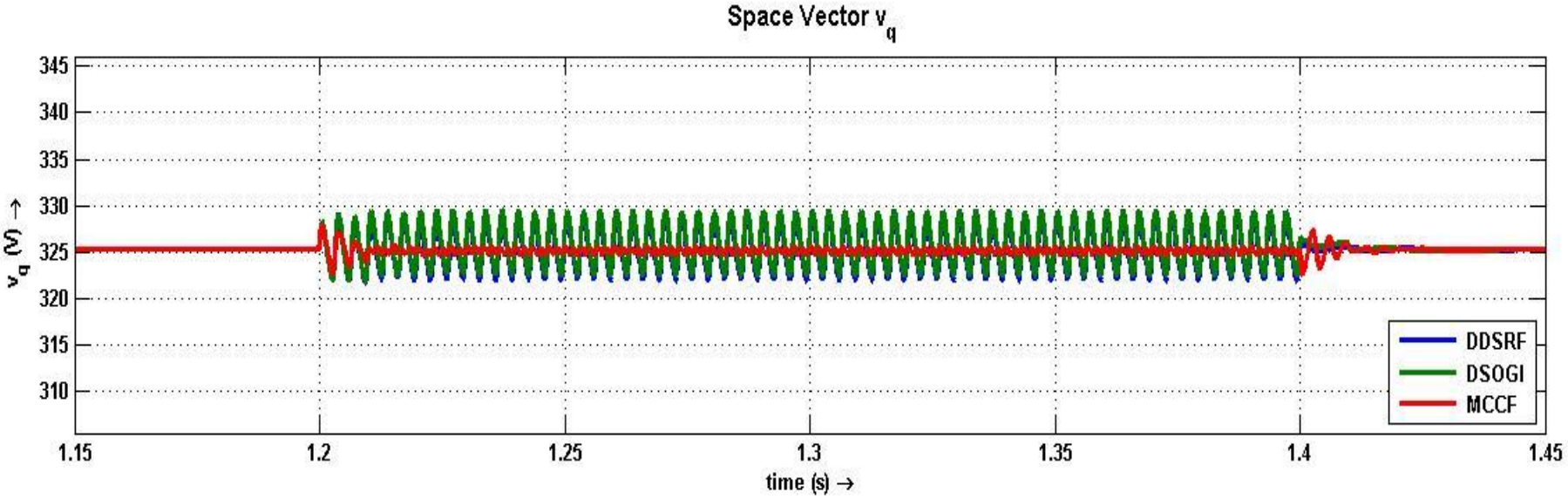

DDSRF, DSOGI, MCCF on Harmonics + Unbalanced Grid

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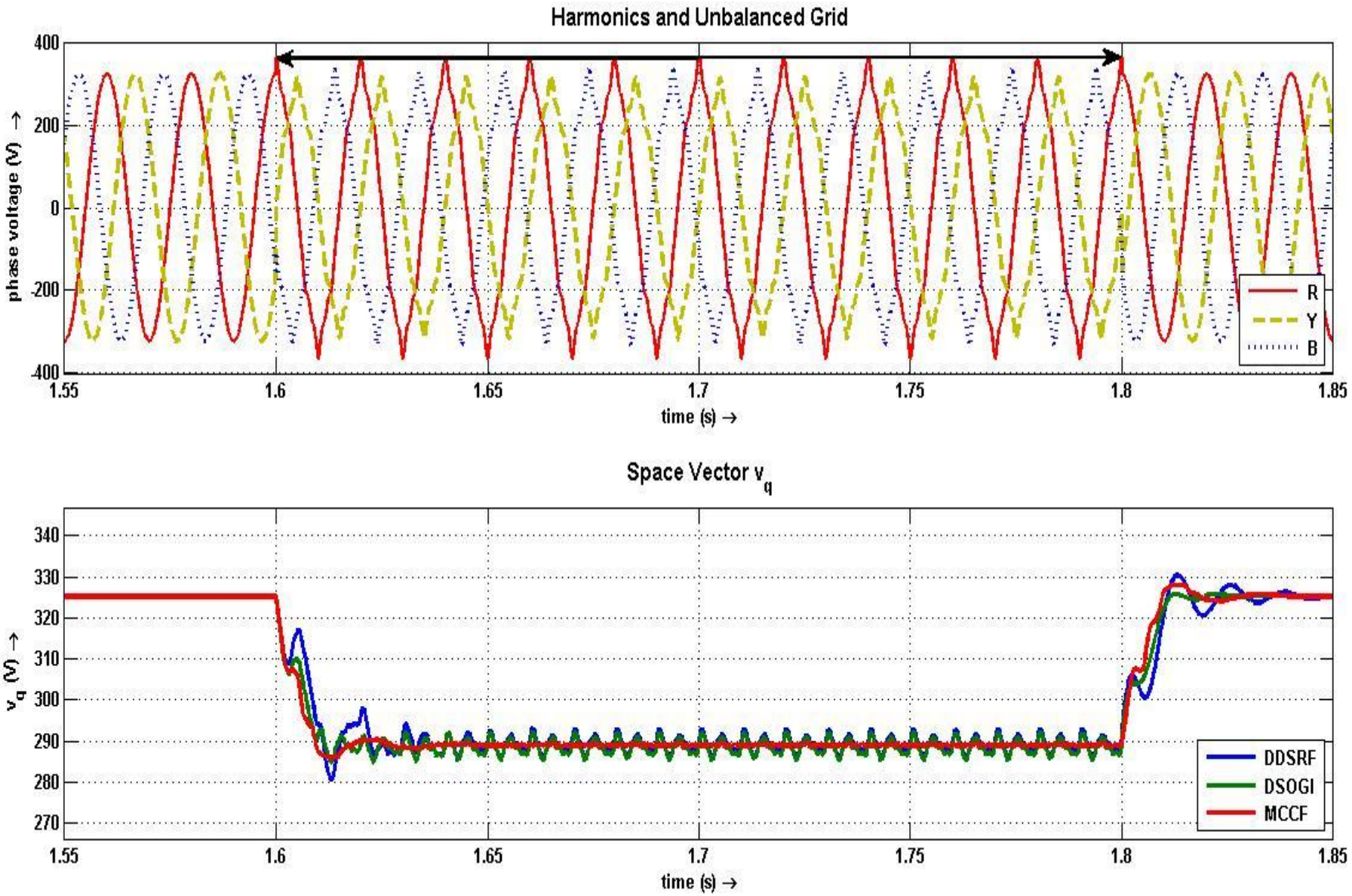

DDSRF, DSOGI, MCCF on Frequency Excursion

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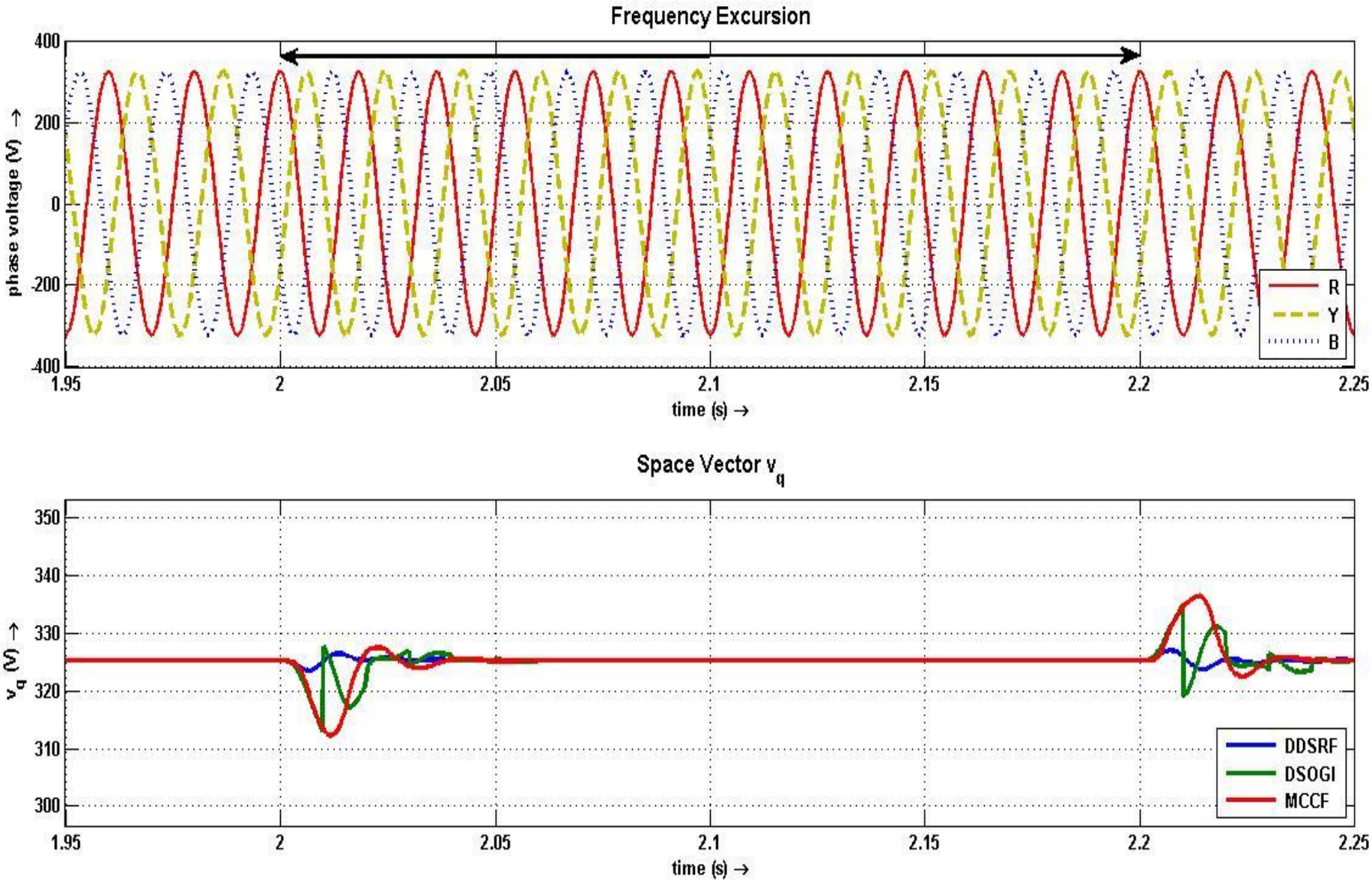

Discrete PLL on Frequency Excursion

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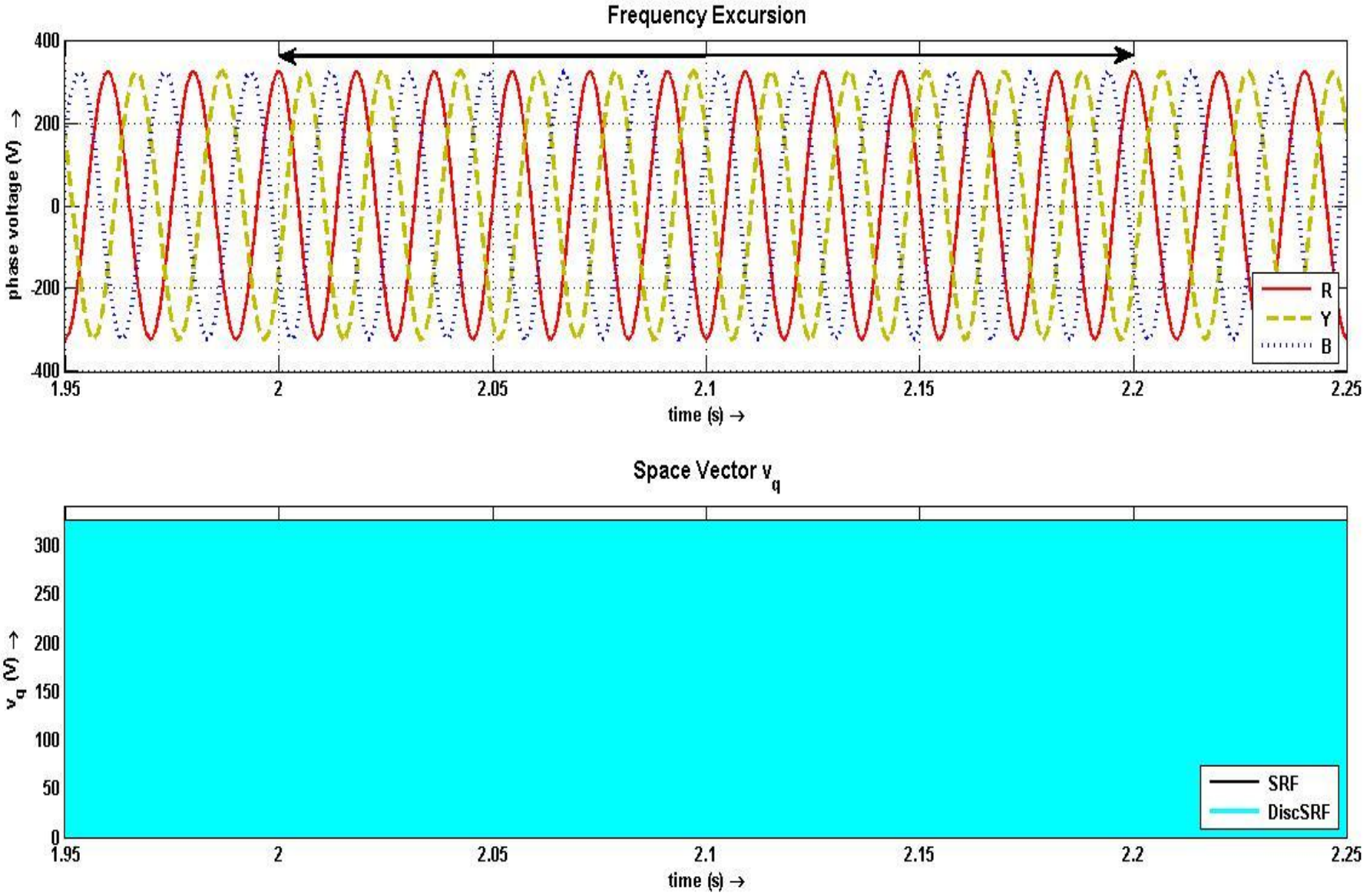

Discrete PLL on Harmonics

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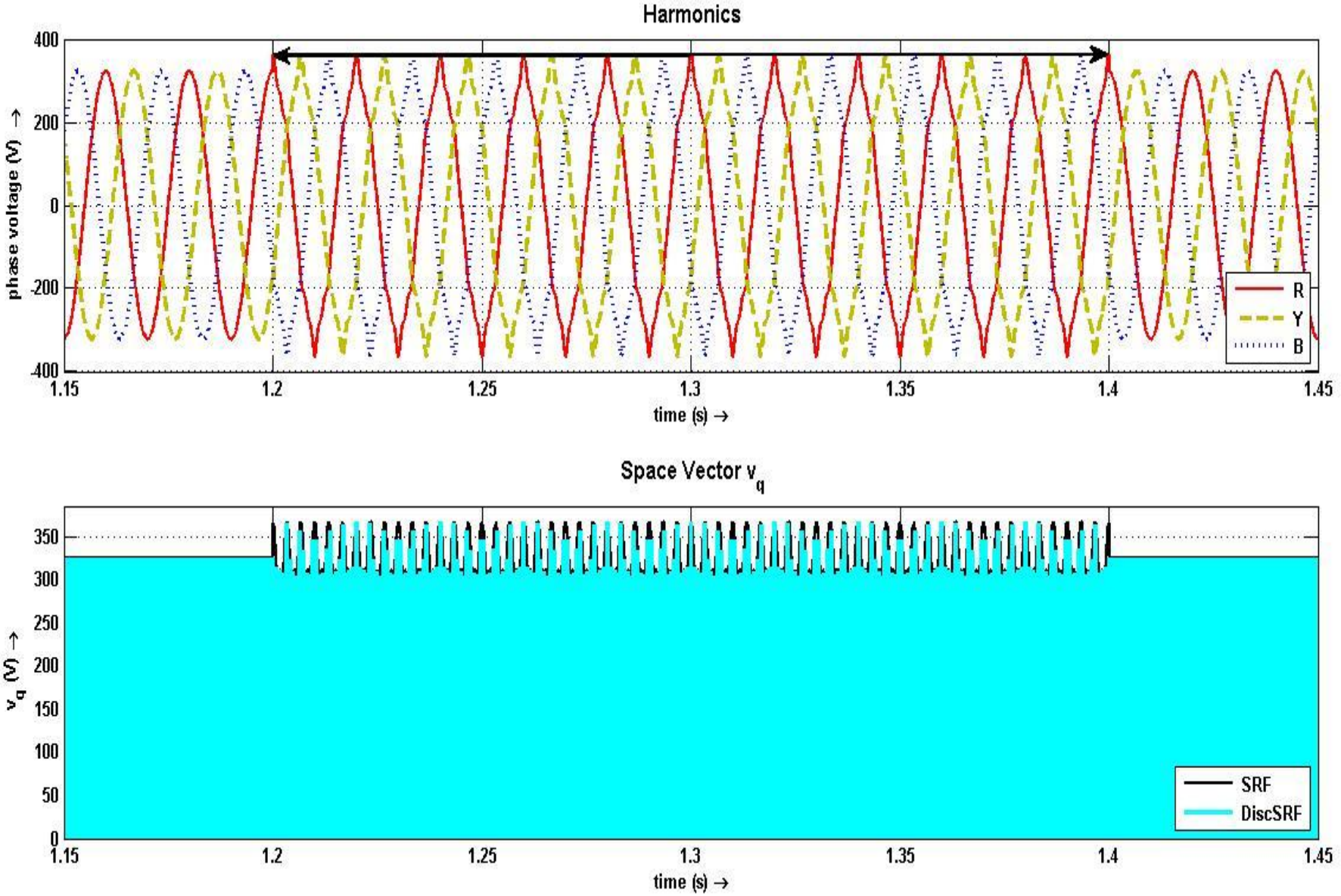

Discrete PLL on Unbalanced Grid

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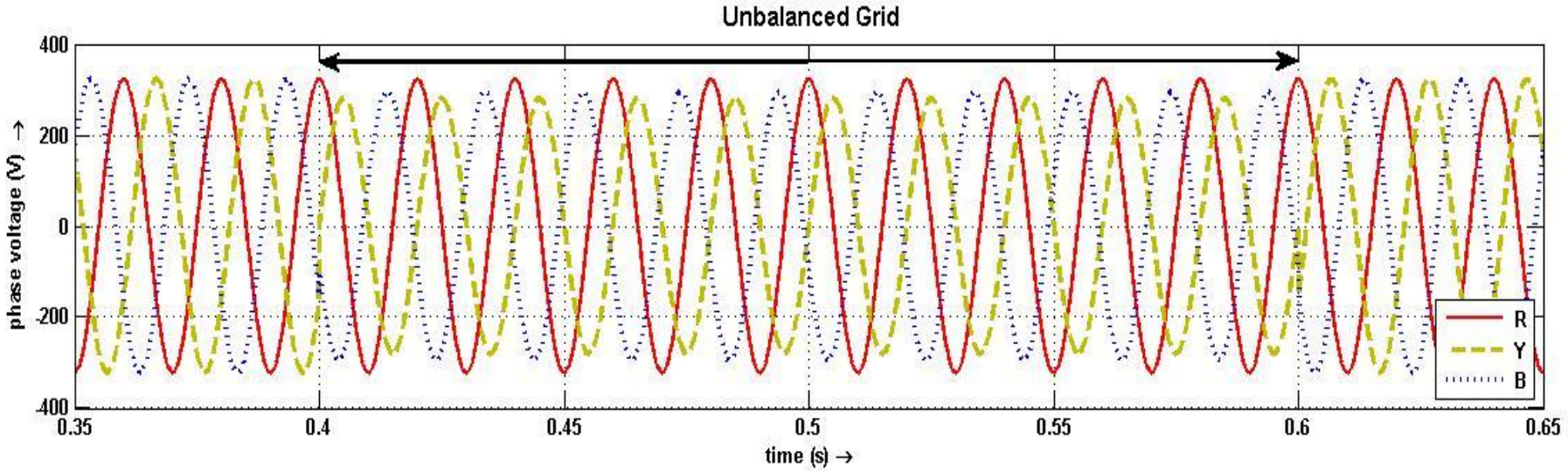

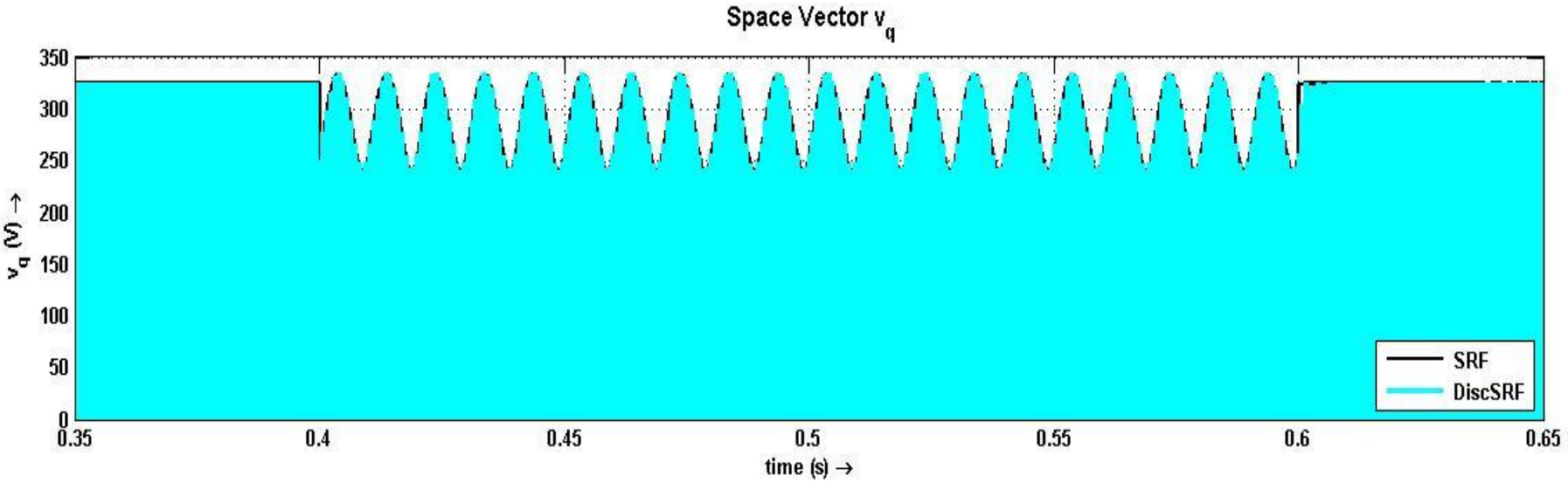

Discrete PLL on Harmonics + Unbalanced Grid

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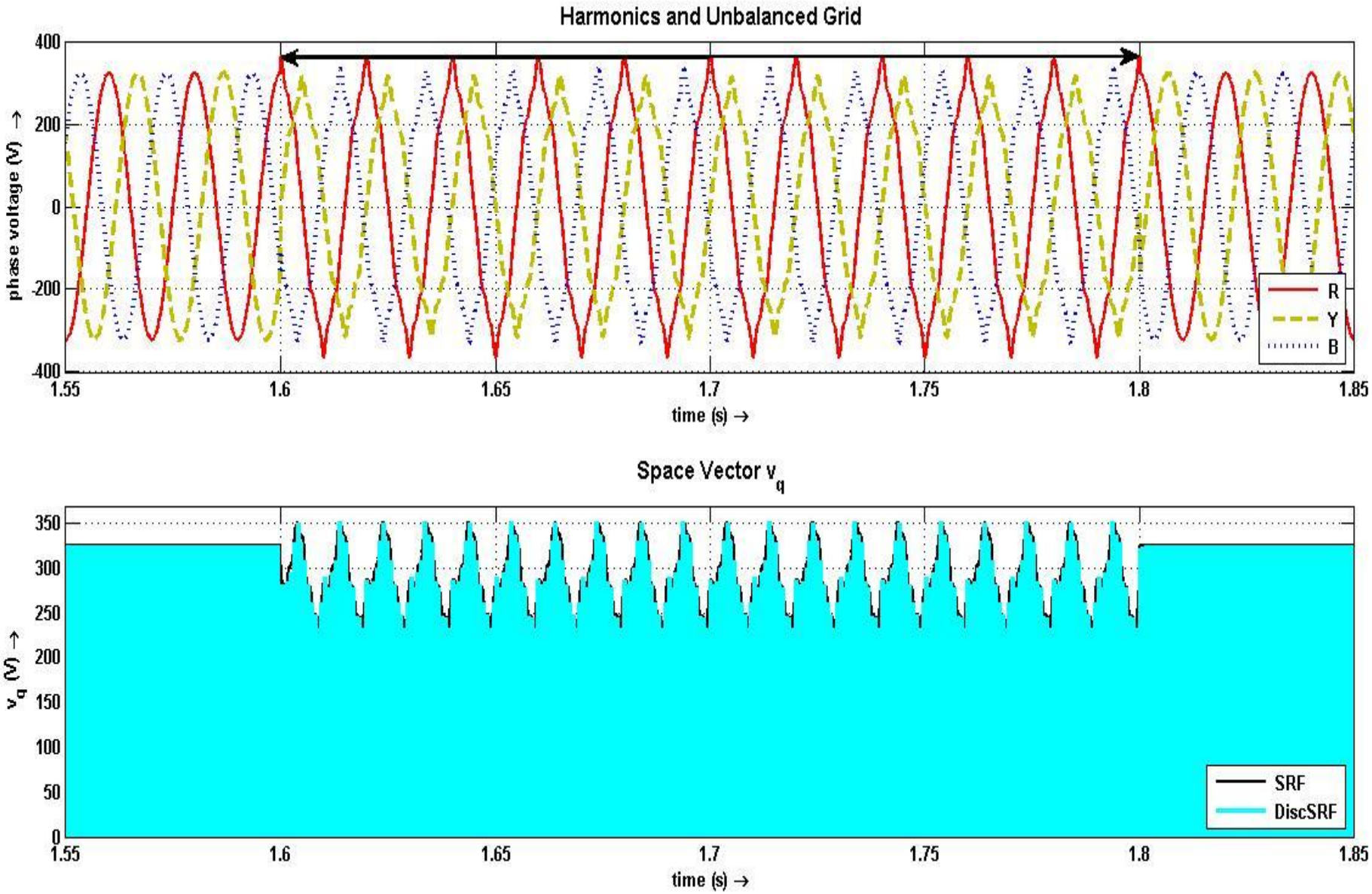

Discrete PLL on L-G Fault

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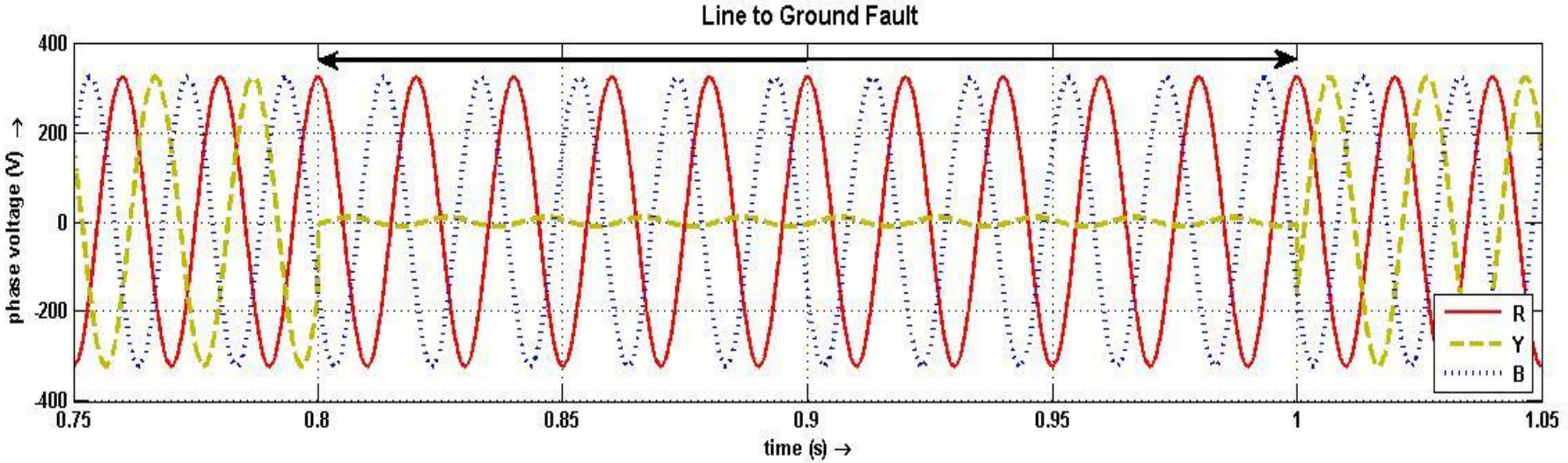

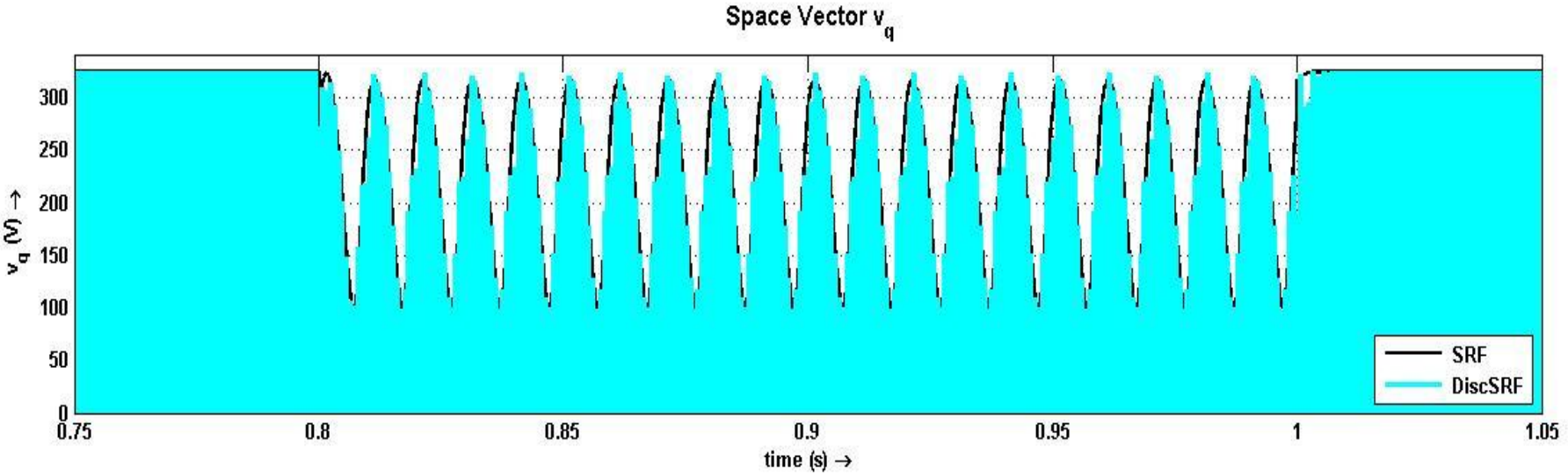

Conventional SRF PLL

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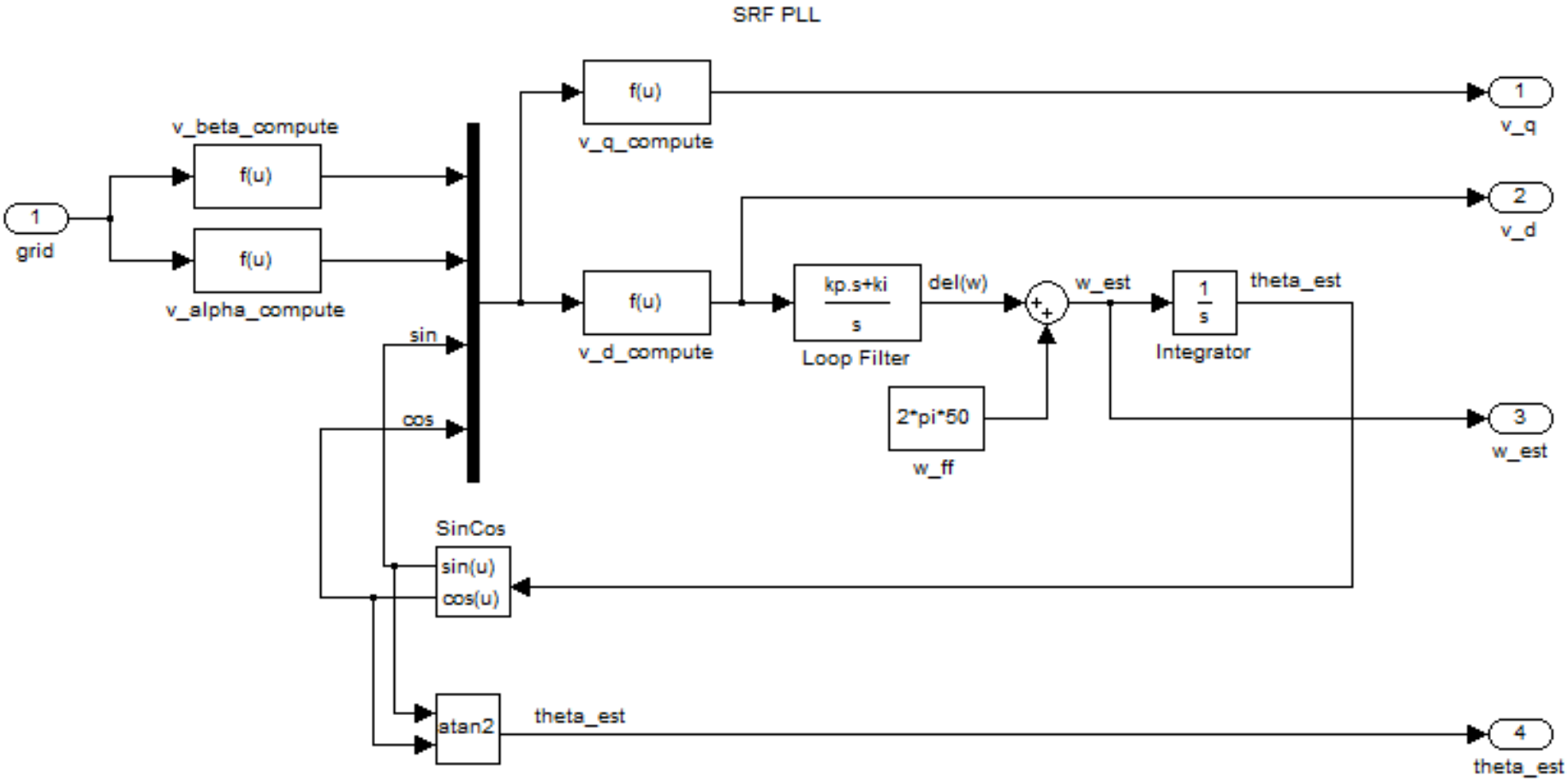

DDSRF PLL

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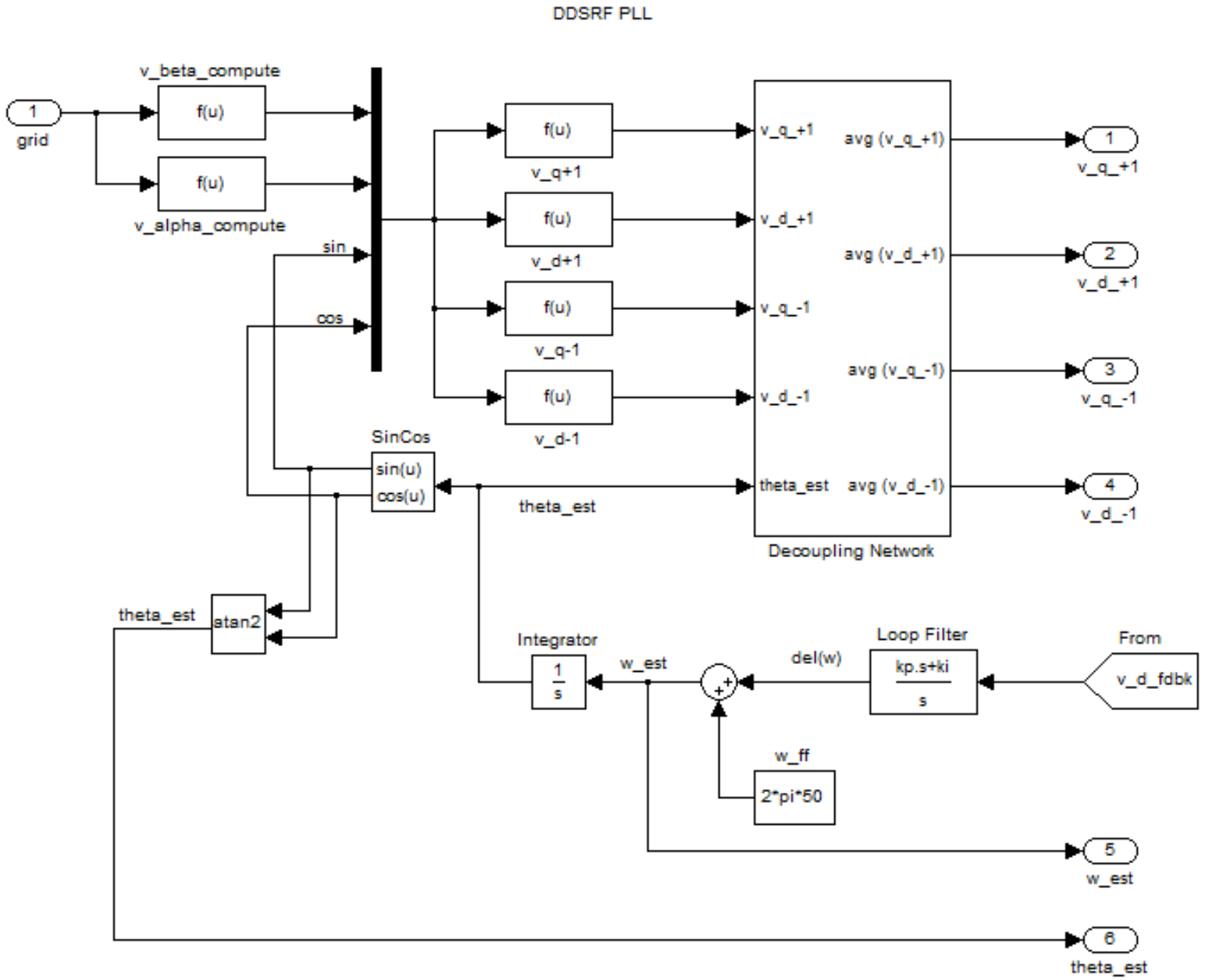

DSOGI PLL

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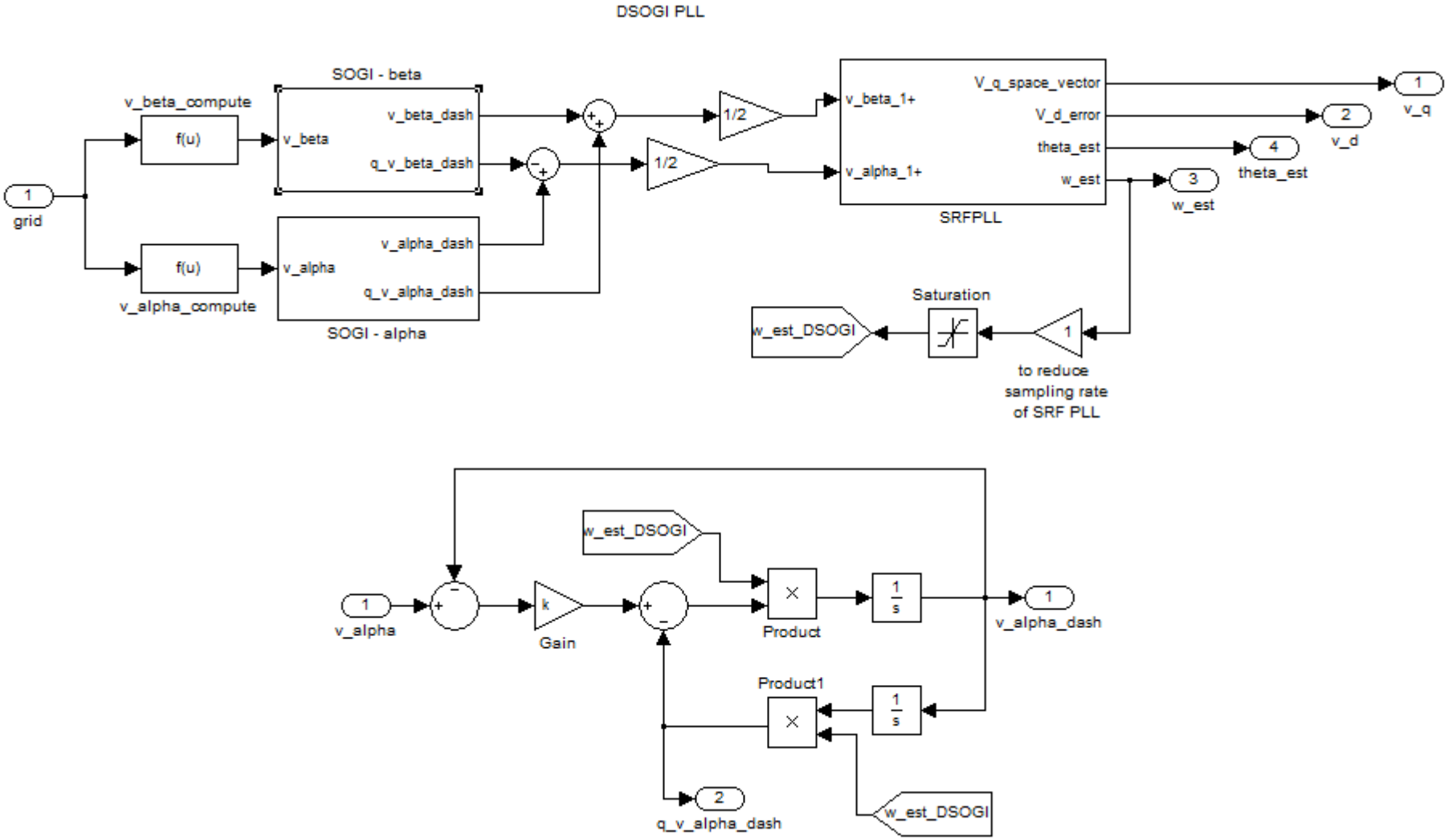
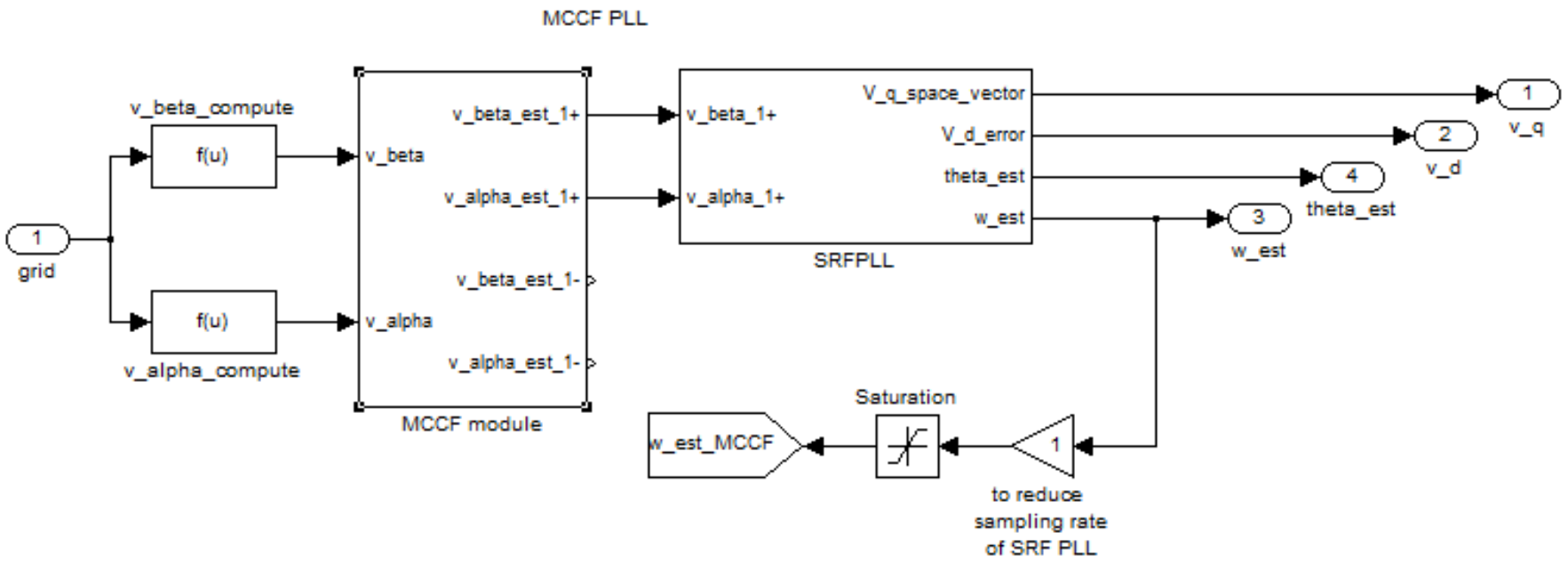


MCCF PLL


MCCF PLL
v_beta_compute
f(u)
v_alpha_compute
f(u)
1
grid
v_beta
v_alpha
v_beta_est_1+
v_alpha_est_1+
v_beta_est_1-
v_alpha_est_1-
MCCF module
v_beta_1+
v_alpha_1+
V_q_space_vector
V_d_error
theta_est
w_est
SRFPLL
1
v_q
2
v_d
4
theta_est
3
w_est
Saturation
w_est_MCCF
1
to reduce
sampling rate
of SRF PLL

MCCF module (continued)

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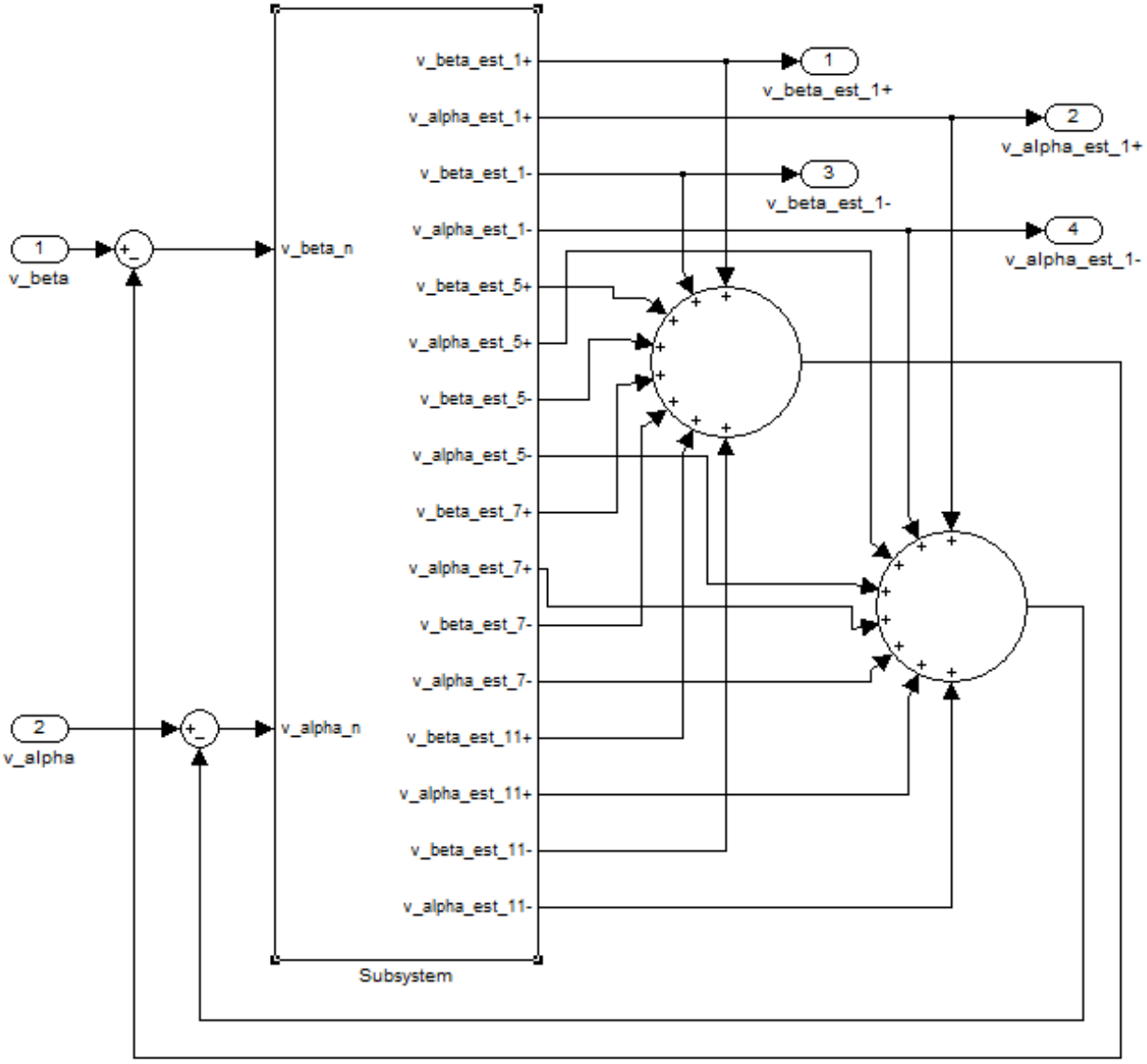

Discrete SRF PLL

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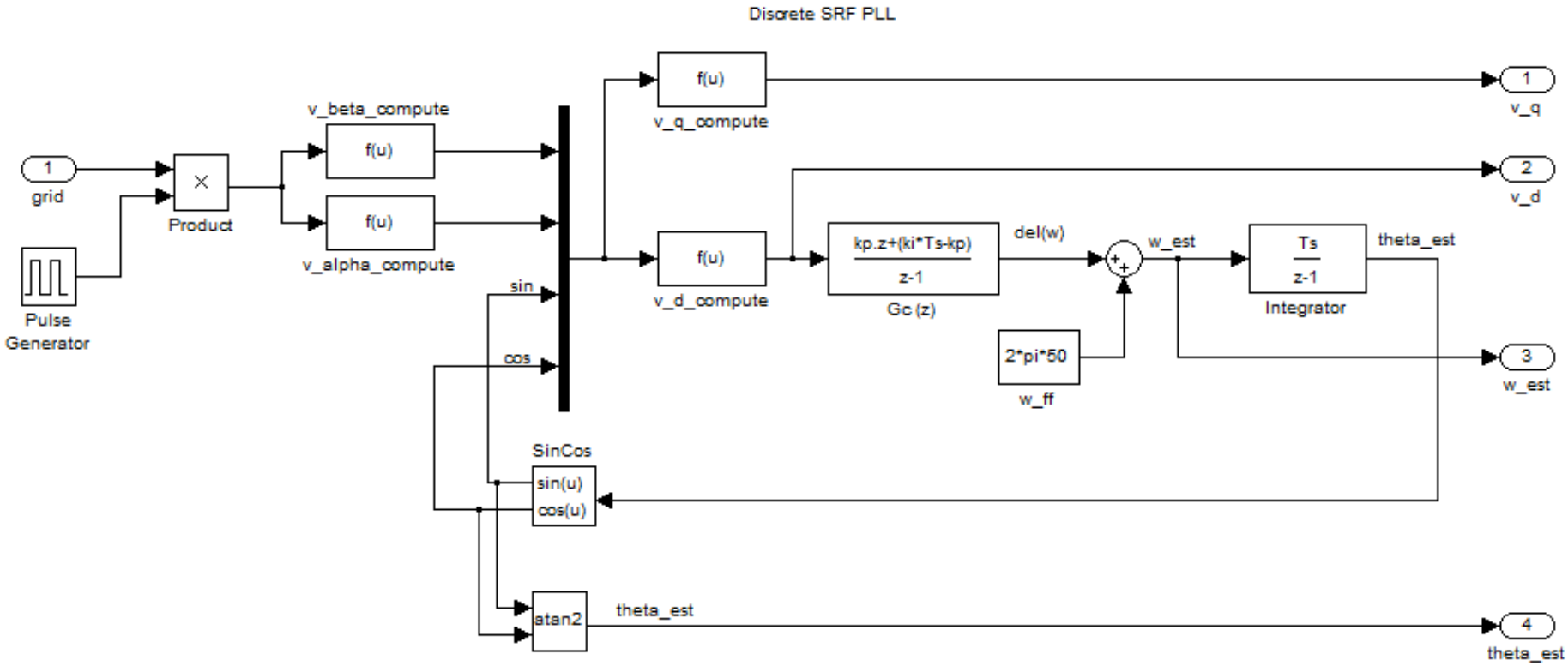

Convention followed

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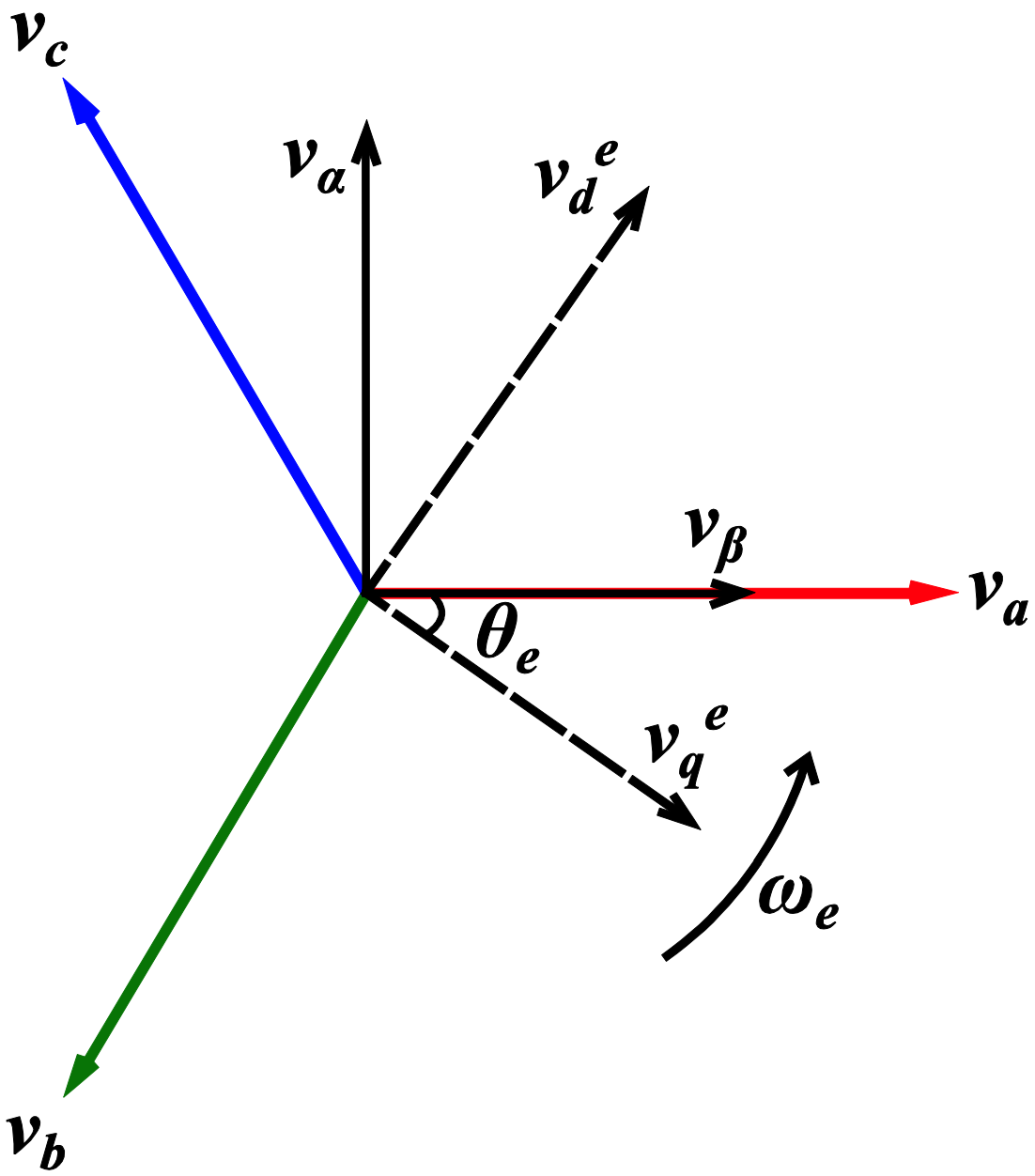
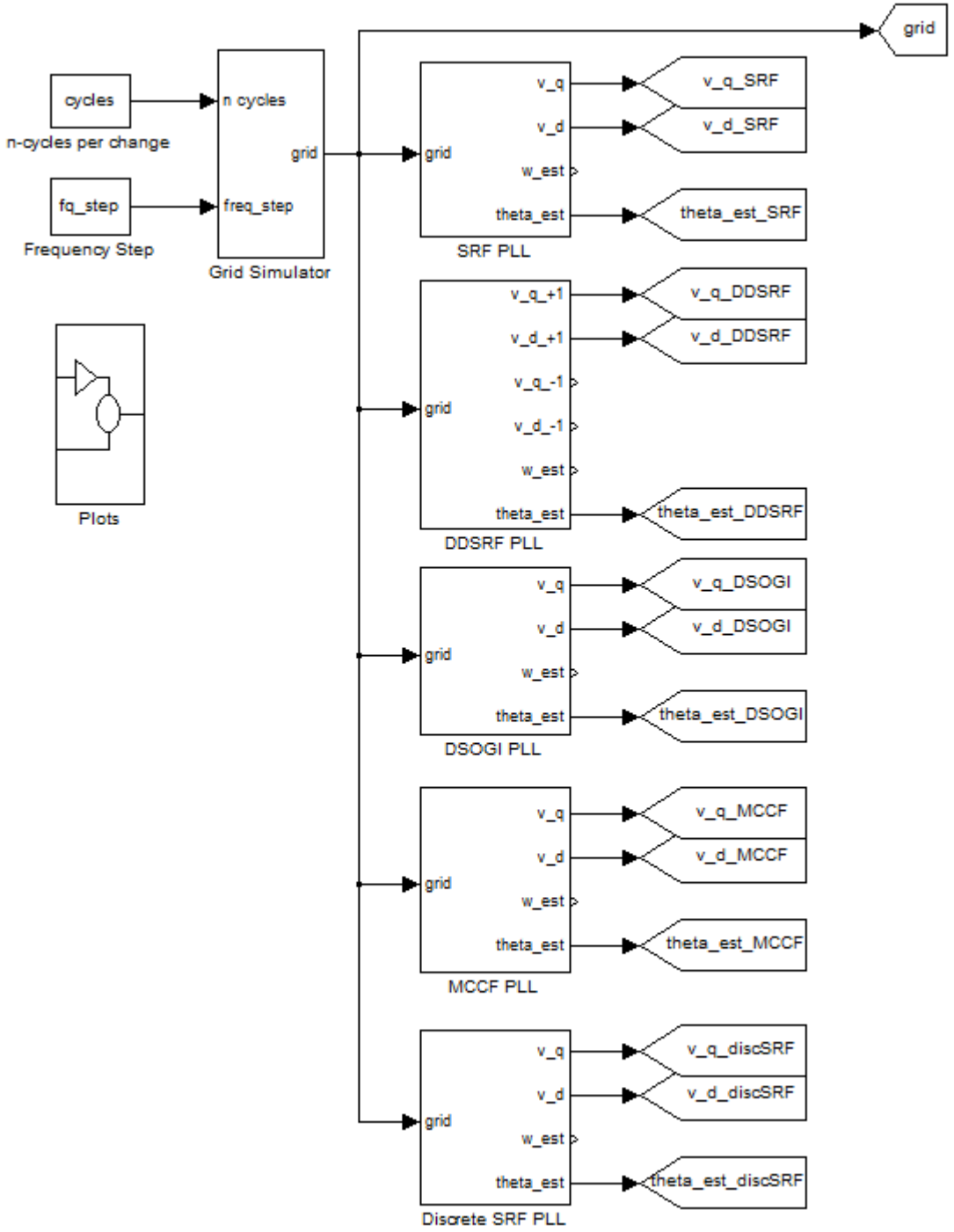
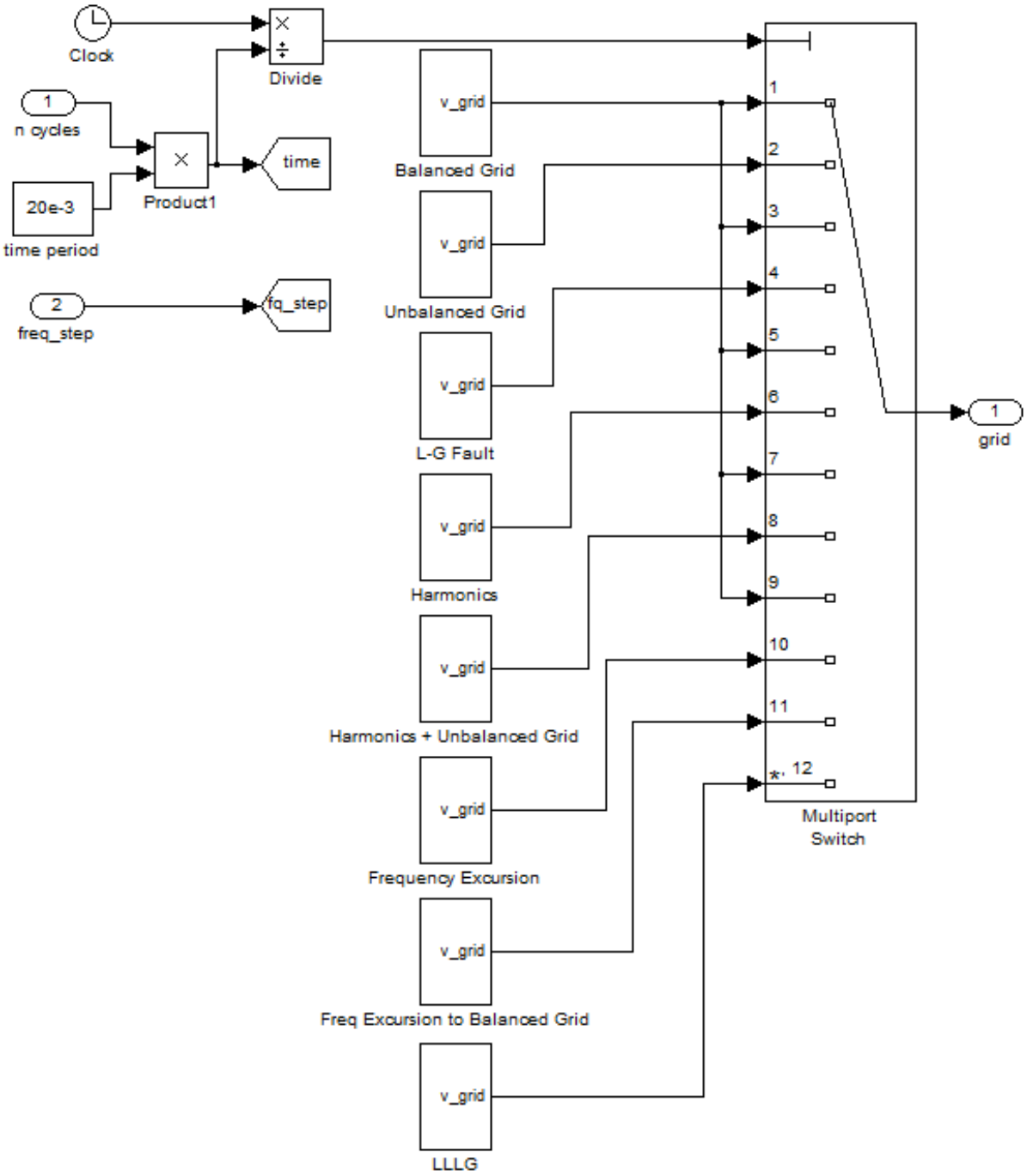


Self-consistent model



Grid simulator



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