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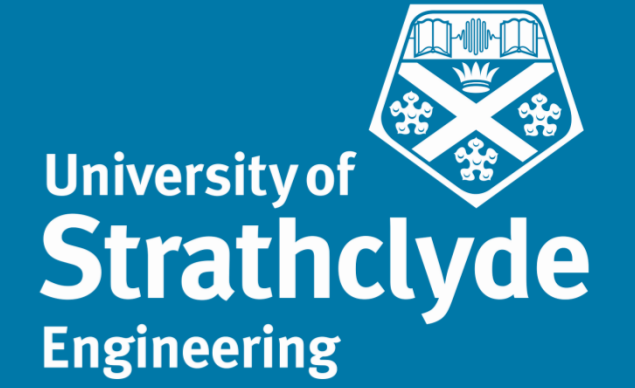
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Predictive Capabilities of Linearised Models for Converter-Interfaced Battery Storage in LV Networks

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1. Background

- Converter-interfaced resources are becoming increasingly ubiquitous in low voltage (LV) power networks
- Time-series analysis can be computationally demanding and thus time consuming
- Linearised models of converters can provide advantages over models used for time-series simulations, demonstrated in this poster

2. Advantages of Linearised State-Space Models

- Linearised models are computationally less demanding than non-linear models, giving faster simulation times.
- Linearised models can be used for time or frequency domain analyses.
- Frequency domain analyses with linear models enables each frequency to be evaluated independently, making it easy to embed frequency dependence of system elements
- Linear models can quickly identify *where* problems are

3. Representation of a Converter and Power System

- Fig.1 can be linearised and utilised for state-space analysis, as shown in Fig. 2,
- The current controller, the network response, etc are highlighted within the dotted boxes

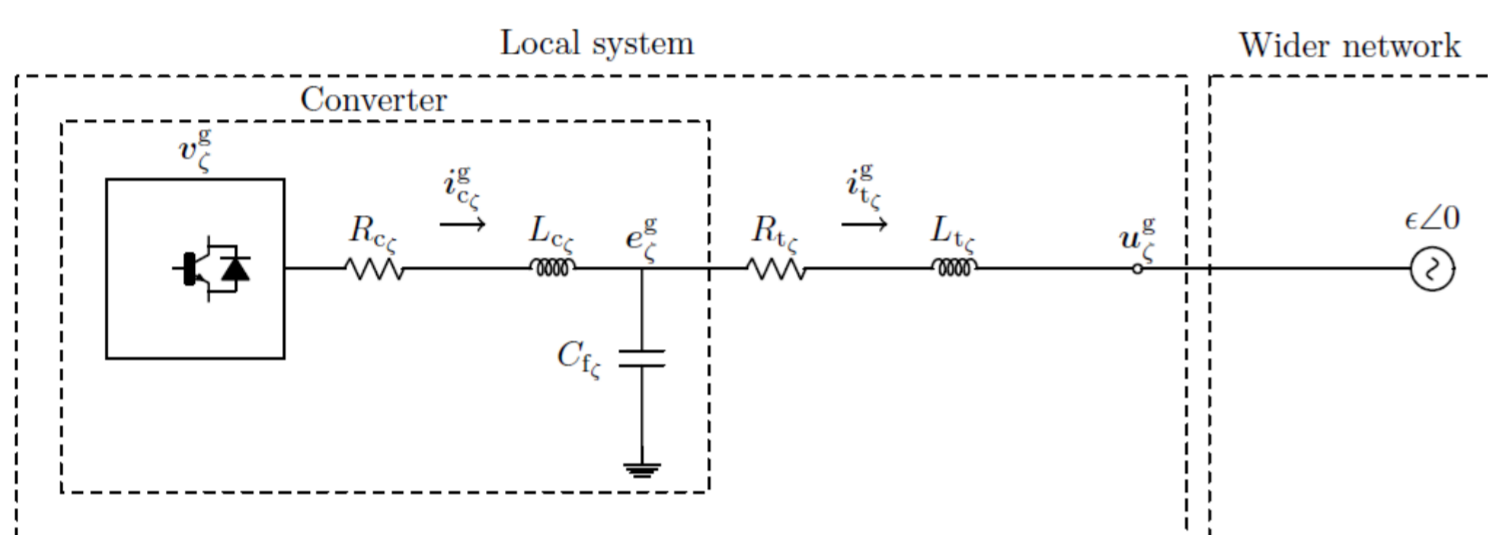


Figure.1 - Representation of a converter with an LC-filter, grid impedance, and wider network.

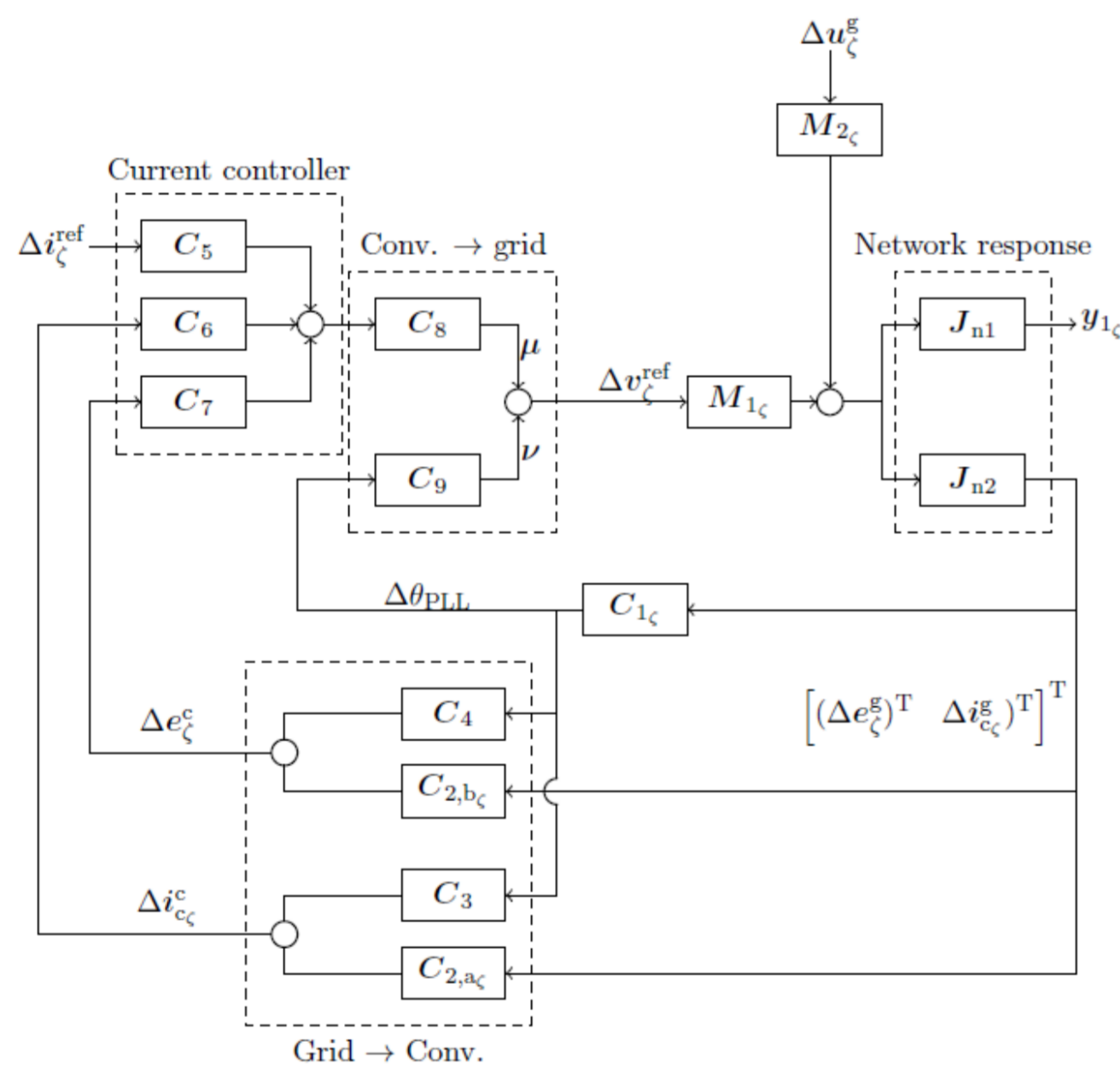


Figure. 2. Block diagram for linearised state-space model for system (Fig. 1) with embedded PLL dynamics

- PLL dynamics incorporated into state-space model (C1, C3, C4 and C9) → this provides greater accuracy

5. Conclusions and Future Work

- Fig. 4 verifies the effectiveness of the linearised state-space approach → Frequency scanning (red dots) verify accuracy
- This work demonstrates the capabilities of state-space modelling for predicting the performance of a single converter in a typical LV network (R/X ratio ≥ 1)
- Future work will incorporate outer loop and droop control to analyse and improve local/decentralised converter control performance on LV networks
- The approach for one converter will also be 'recycled' to enable modelling of multiple converters for system analyses (e.g. as shown in Fig. 5) – key to predicting converter control performance and interaction between battery units in LV networks
- Incorporation of state-space model for Li-Ion battery will provide more accurate dynamics by including nonlinearities in battery

4. Results

- When controlling i_d and i_q , it is important to identify the affect that each element has
- This method enables assessment of internal controller stability and any impact upon the system (e.g. voltage) as seen in Fig.4

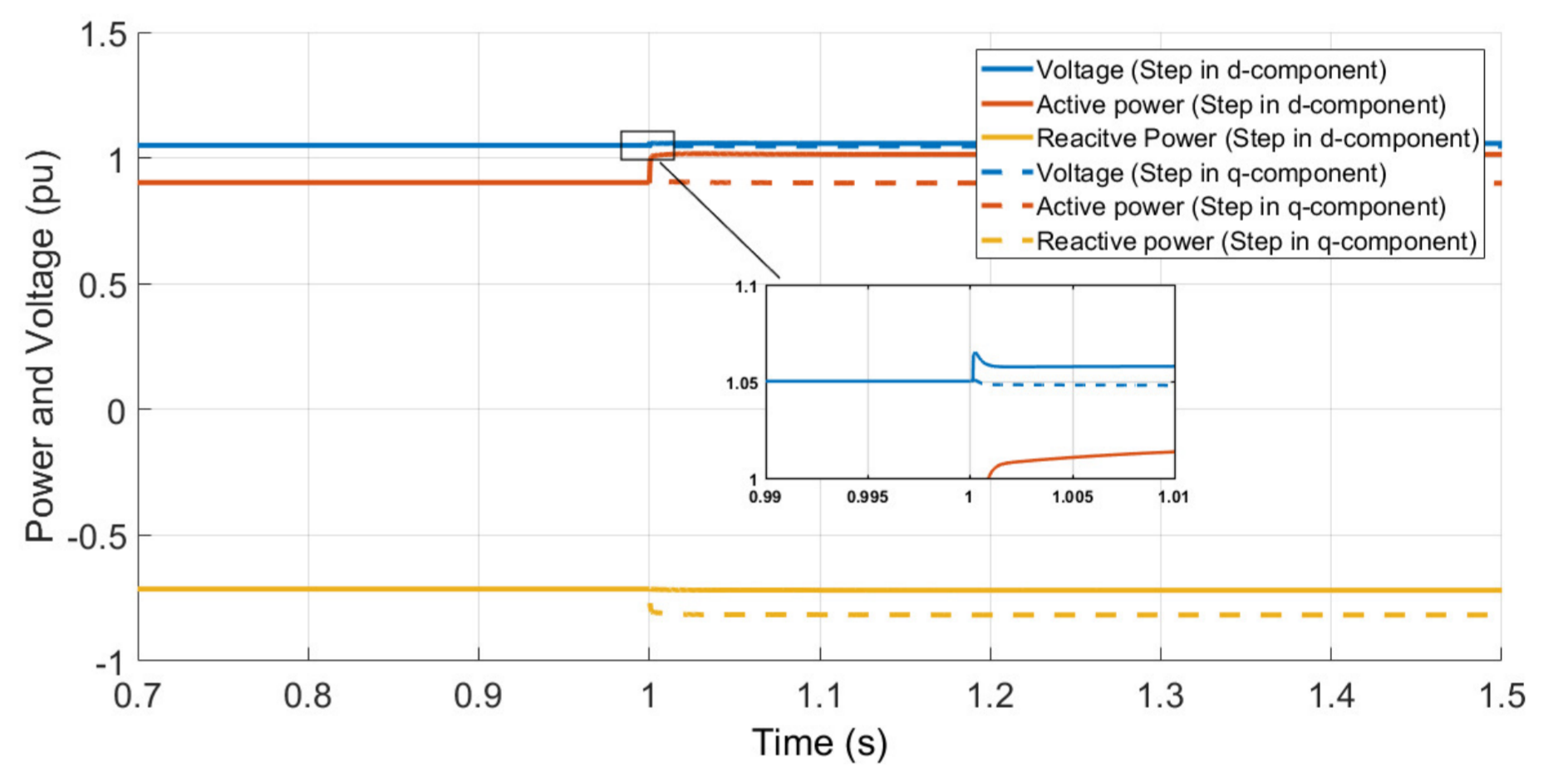


Figure 3. Impact of step changes in i_d and i_q reference on voltage, active, and reactive power

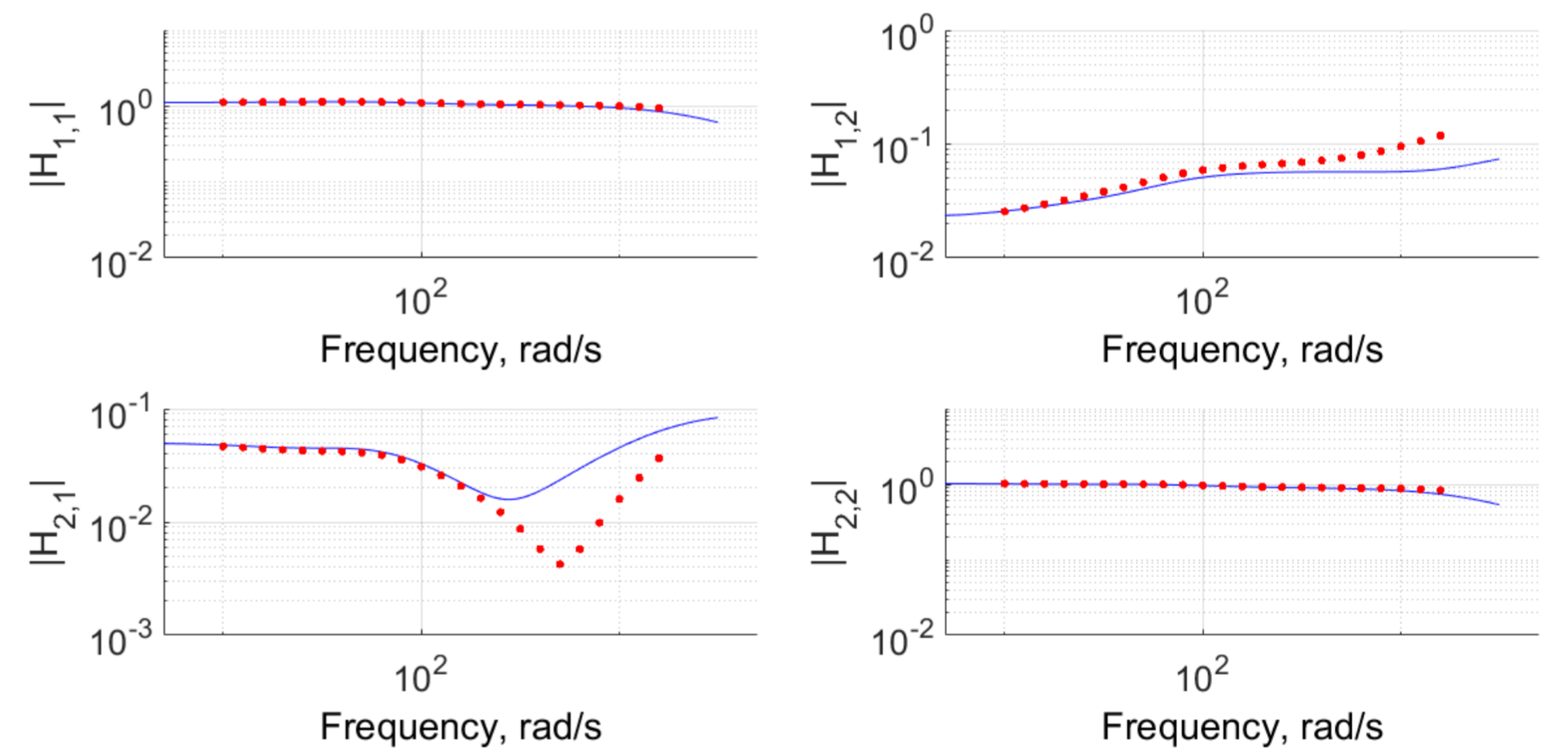


Figure 4. Bode plots for inner current controller, with: (a) Effect of i_d^{ref} on active power (b) Effect of i_q^{ref} on active power (c) Effect of i_q^{ref} on voltage/reactive power (d) Effect of i_d^{ref} on voltage/reactive power

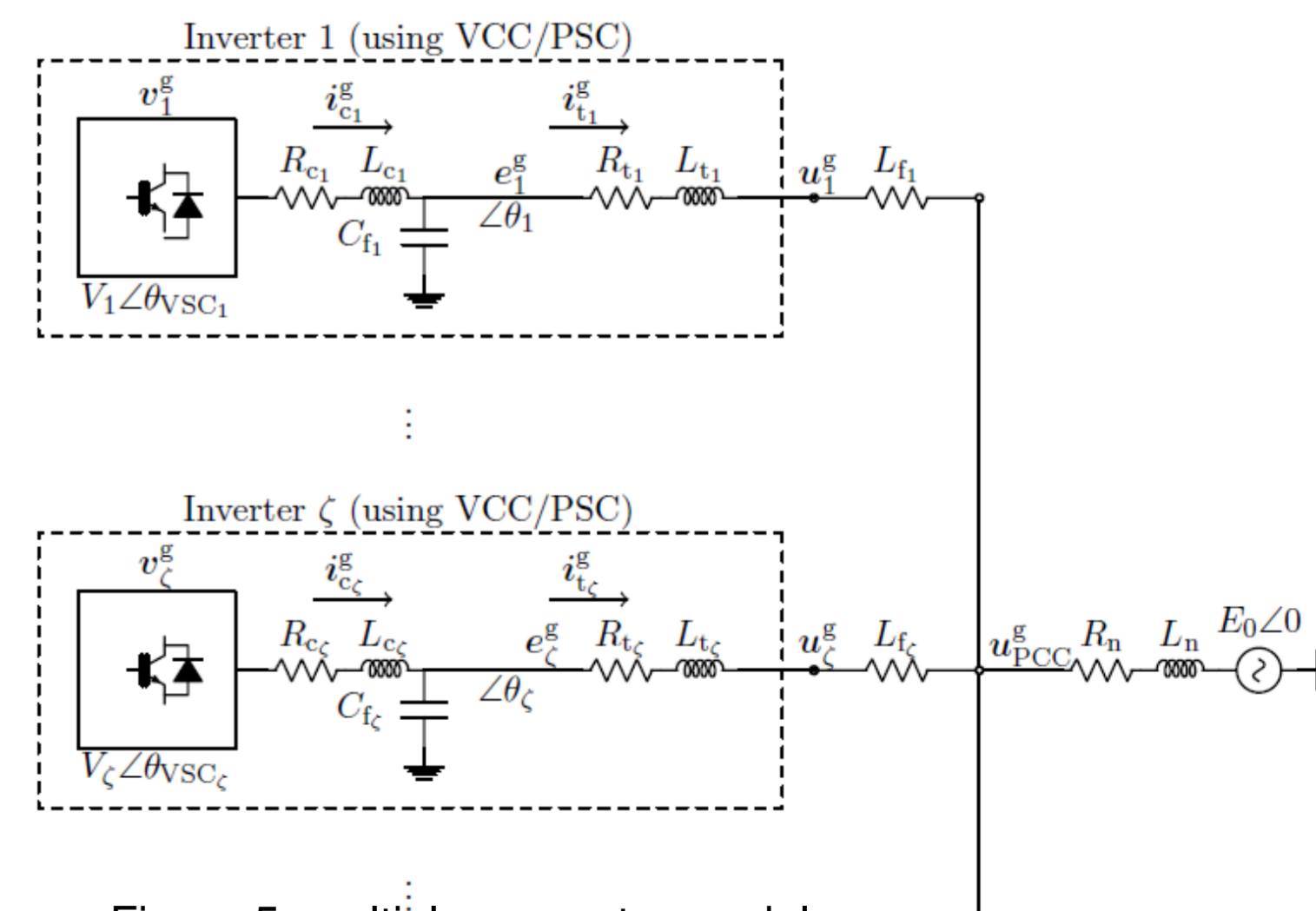


Figure 5. multiple converter model