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

Anthony Florida-James[1], Alexander Giles[1] Graeme Burt[1], Stephen McArthur[1]

1- Institute for Energy and Environment, University of Strathclyde, Glasgow (anthony.florida-james@strath.ac.uk, alexander.giles@strath.ac.uk, grame.burt@strath.ac.uk, s.mcarthur@strath.ac.uk)

University of Strathclyde Engineering

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

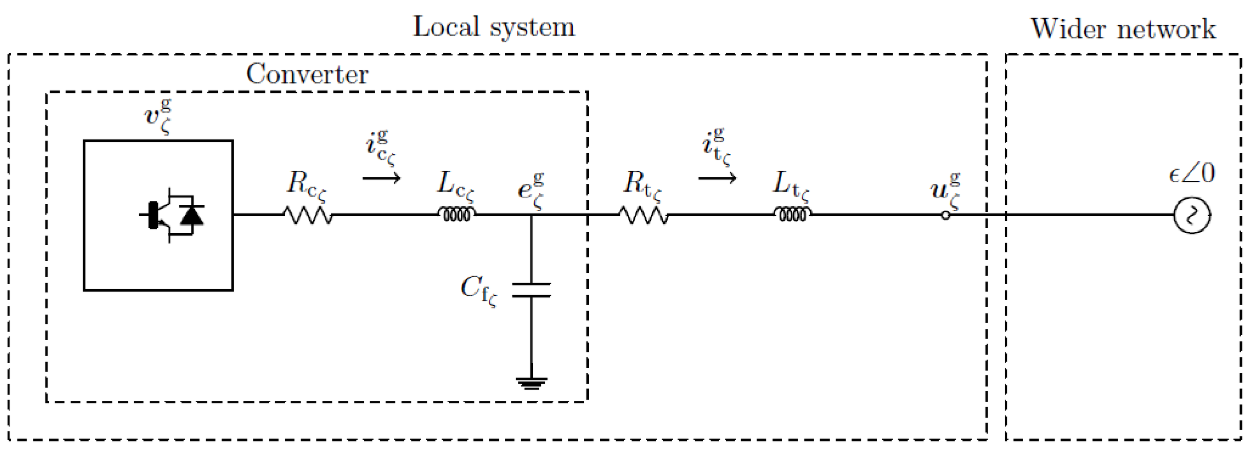

Figure.1 - Representation of a converter with an LC-filter, grid impedance, and wider network.

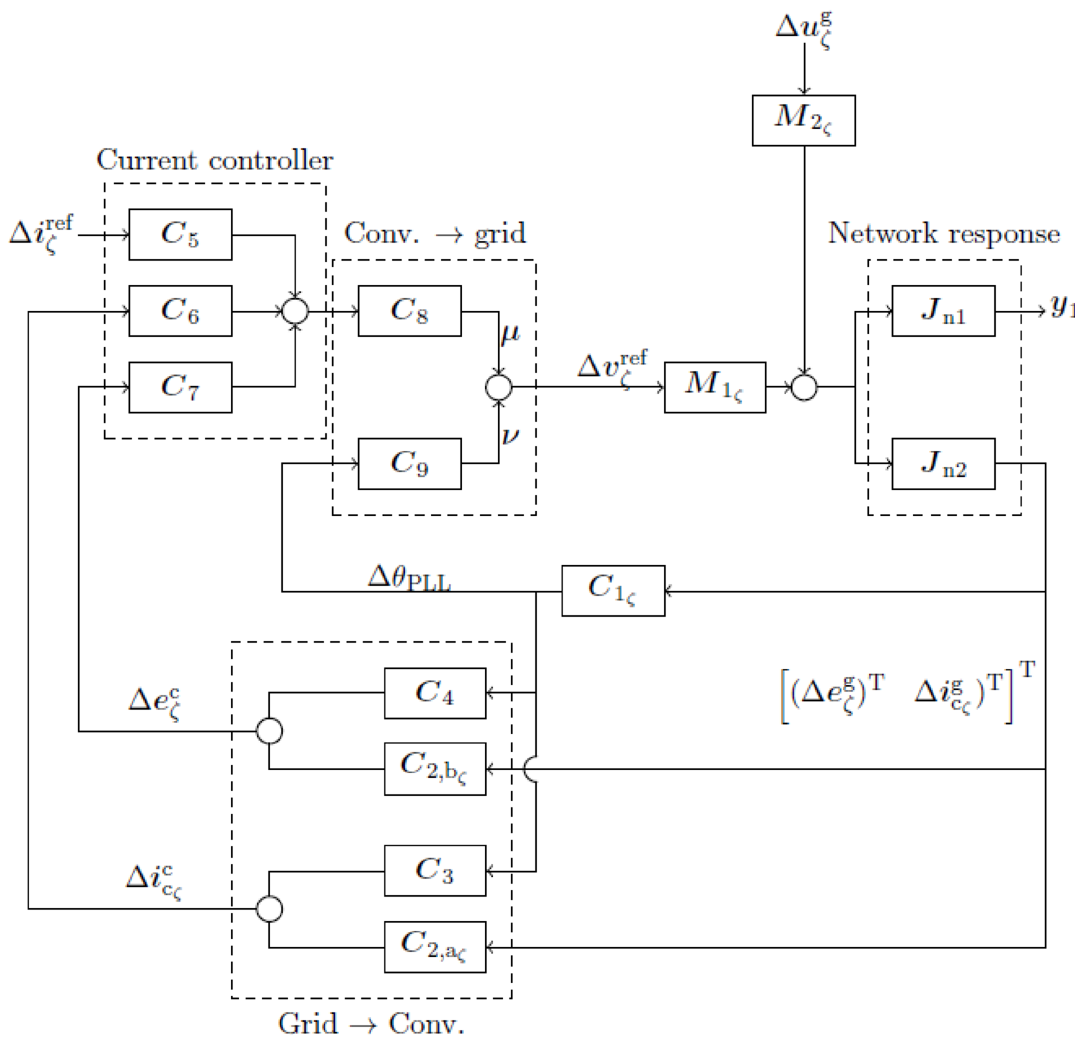

Figure. 2. Block diagram for linearised state-space model for system (Fig. 1) with embedded PLL dynamics

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

4. Results

- When controlling id and iq, 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

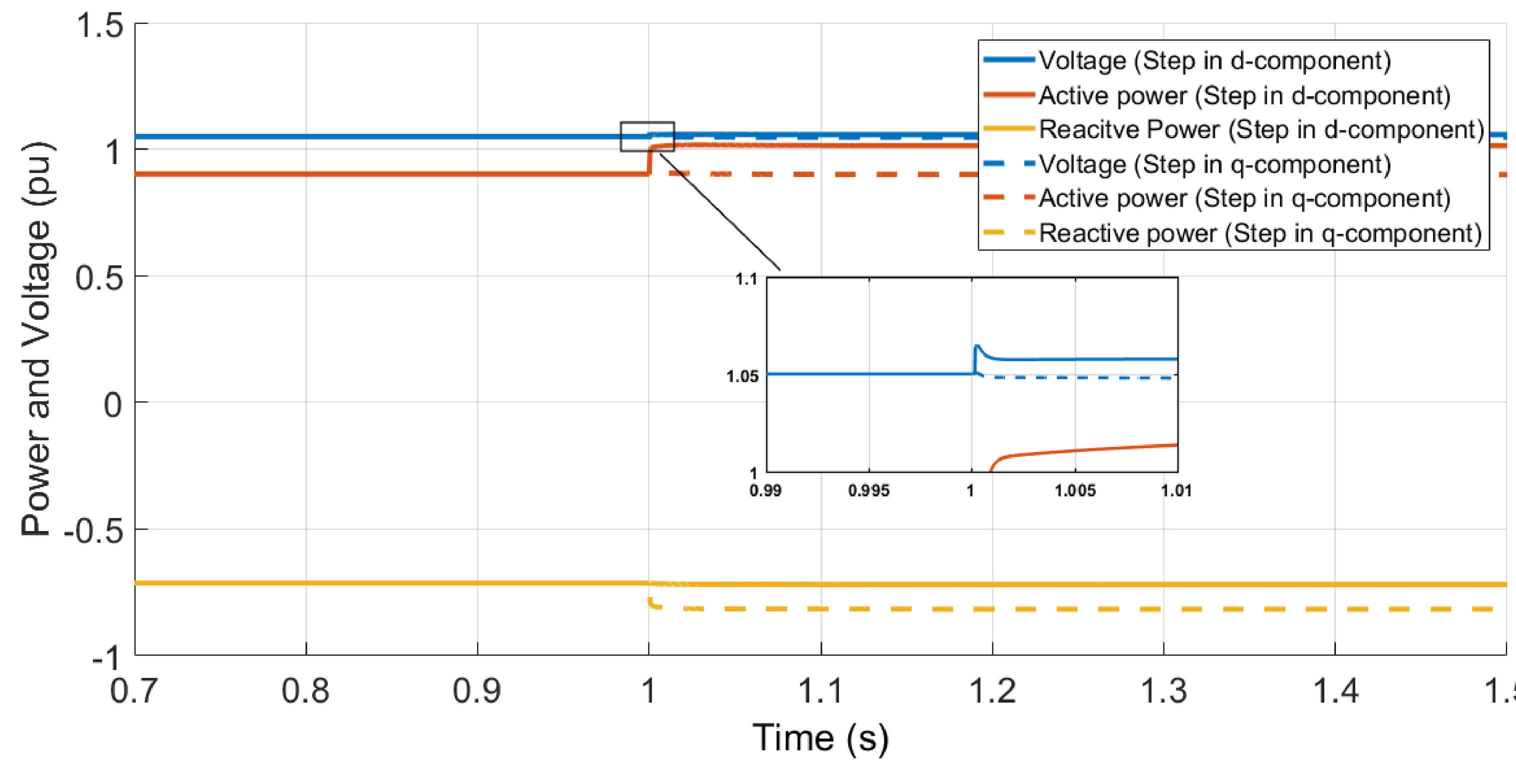

Figure 3. Impact of step changes in id and iq reference on voltage, active, and reactive power

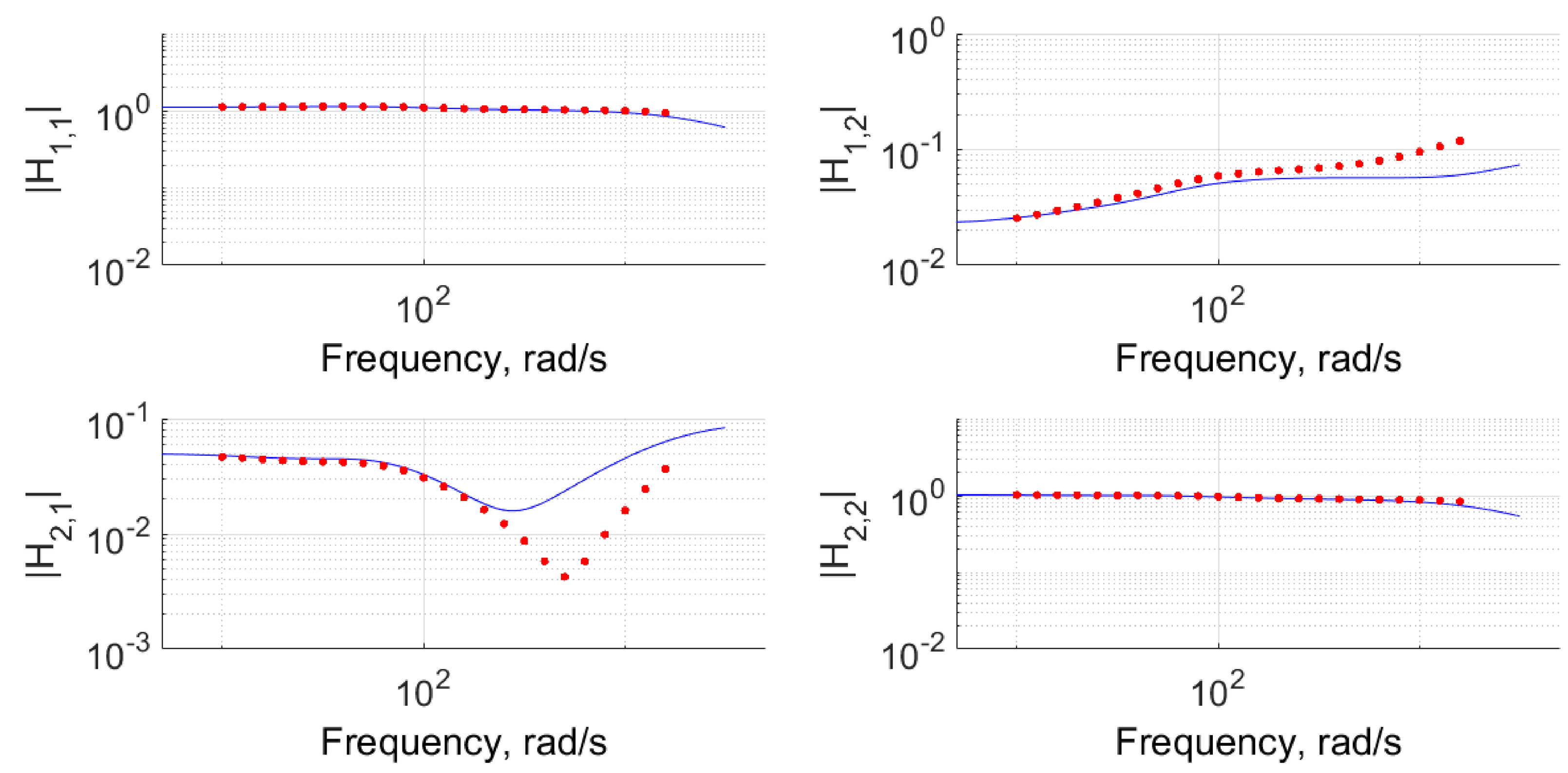

Figure 4. Bode plots for inner current controller, with: (a) Effect of id^{ref} on active power (b) Effect of iq^{ref} on active power (c) Effect of iq^{ref} on voltage/reactive power (d) Effect of id^{ref} on voltage/reactive power

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

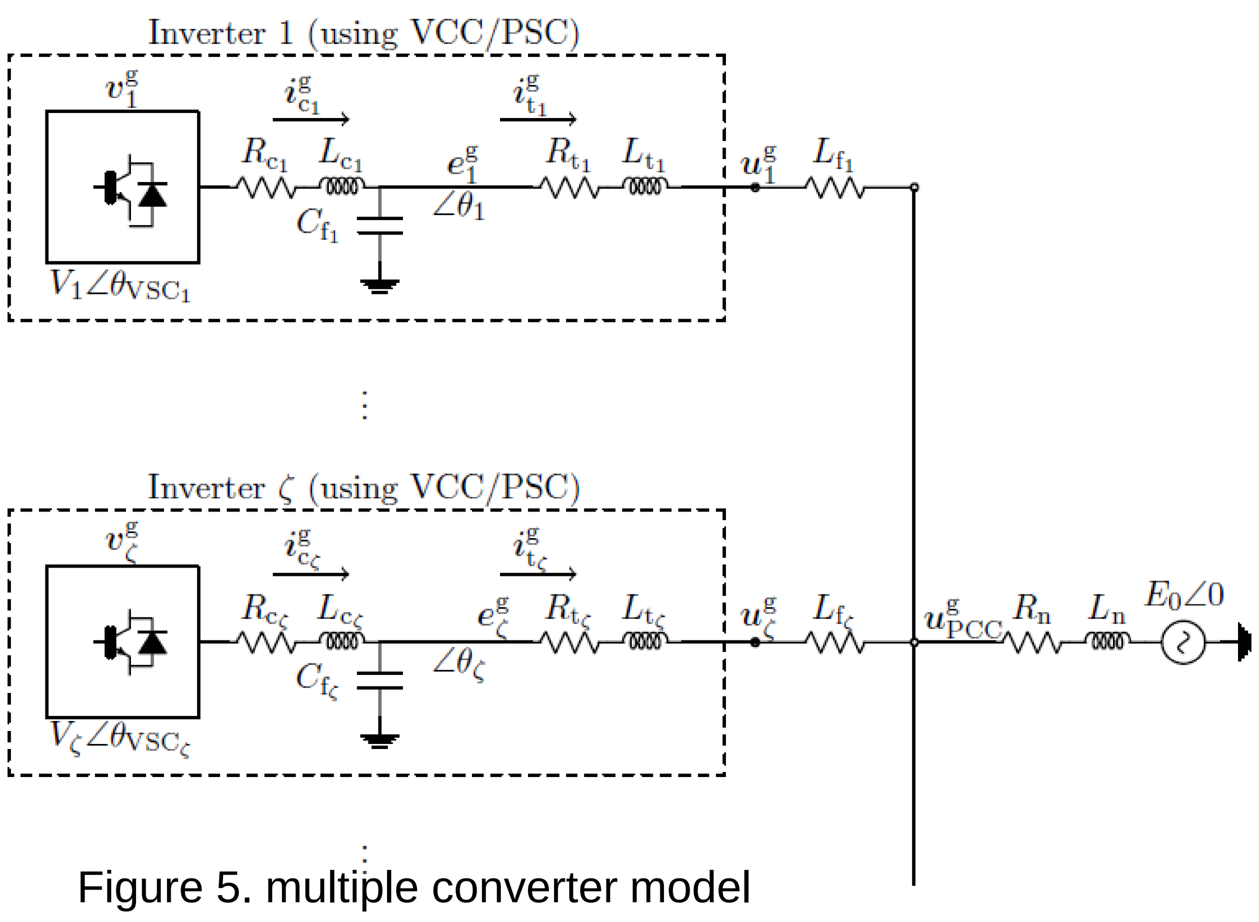

Figure 5. multiple converter model

EPSRC
Engineering and Physical Sciences Research Council