Theme X:
Drive train loads and monitoring

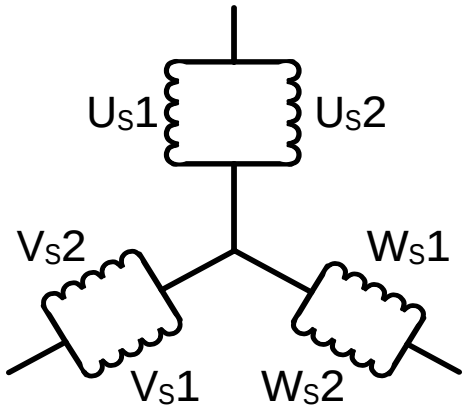
Research at The University of Manchester

Department of Electrical Engineering and Electronics
The University of Manchester

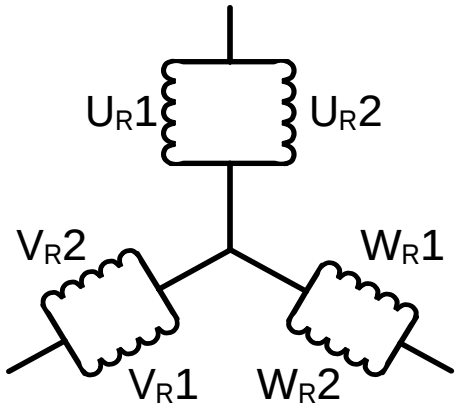
Work so far

- An analytical model for a DFIG has been developed to enable the dynamic behaviour of a generator operating with various healthy and faulty winding configurations to be simulated.
- A 30 kW DFIG test-rig has been built to explore DFIG steady-state operation under a range of winding and supply fault scenarios.
- The analytical model has been verified by comparison of model predictions with test-rig measurements for a series of typical operating points.
- DFIG operation with a range of typical winding faults and supply asymmetries has been explored.
- Changes in the stator current spectrum arising from each fault condition, have been identified.

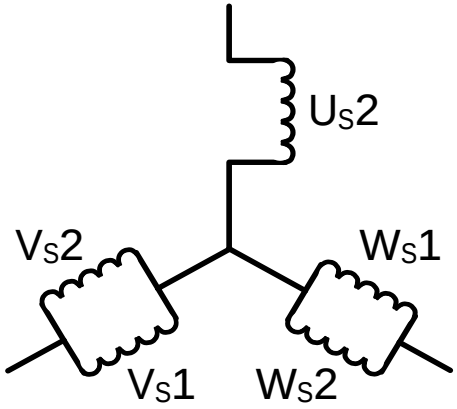
Healthy and faulty DFIG winding configurations used in this presentation



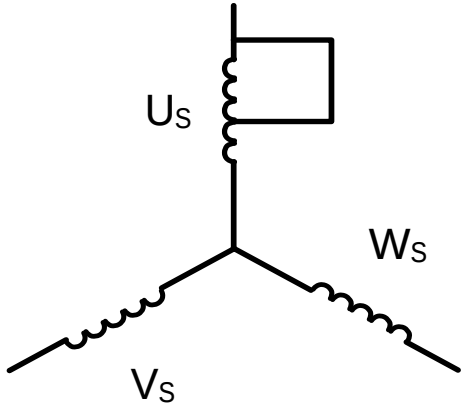
a) Stator healthy



b) Rotor healthy

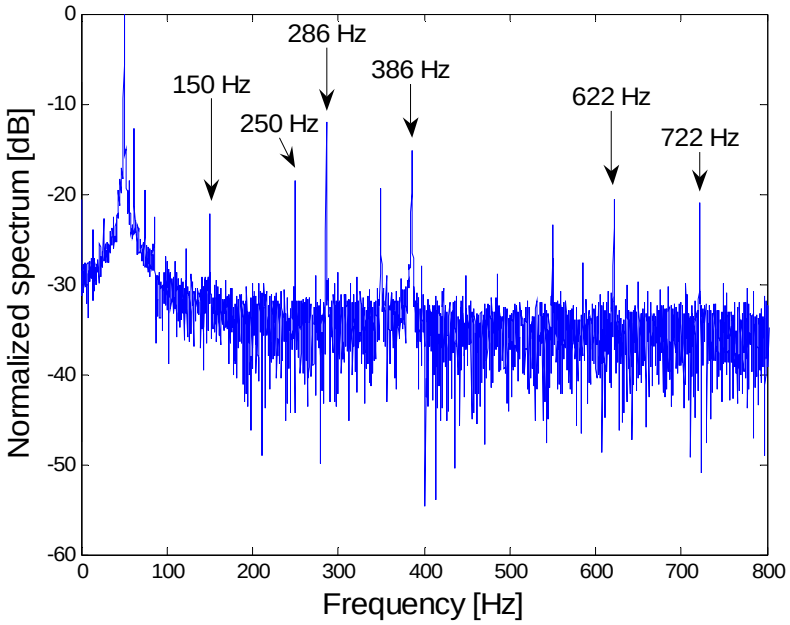


c) Stator open-circuit fault

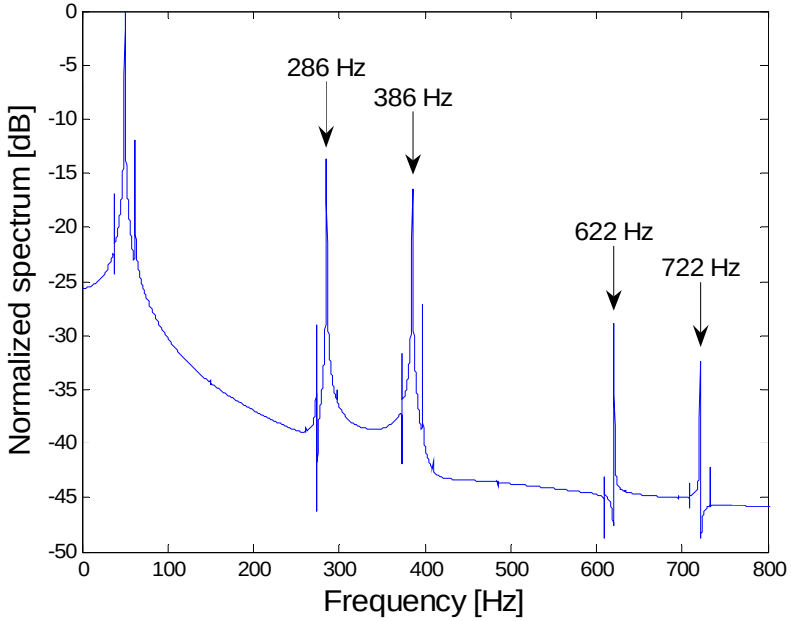


d) Stator short-circuit fault

Frequency content of predicted and measured DFIG stator line current for a DFIG operating with balanced windings and unbalanced supply

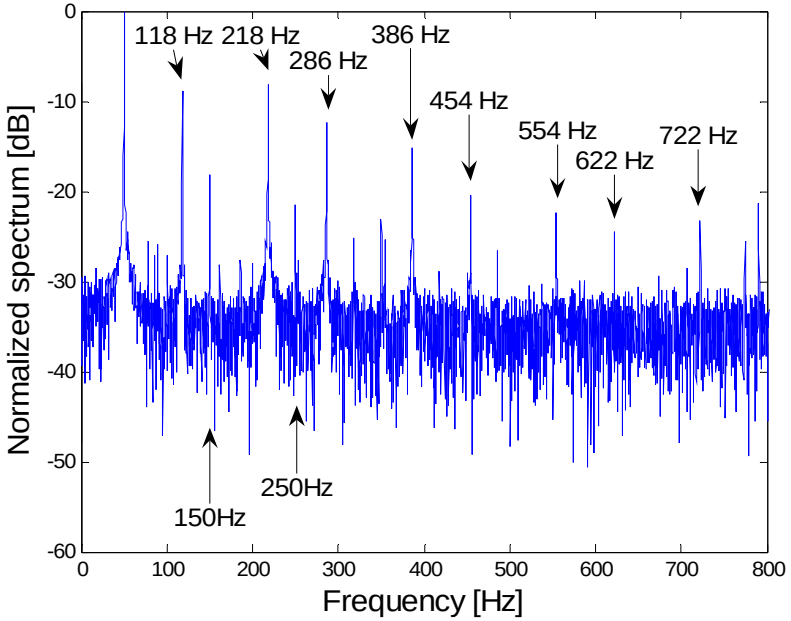


a) Experimental current spectrum

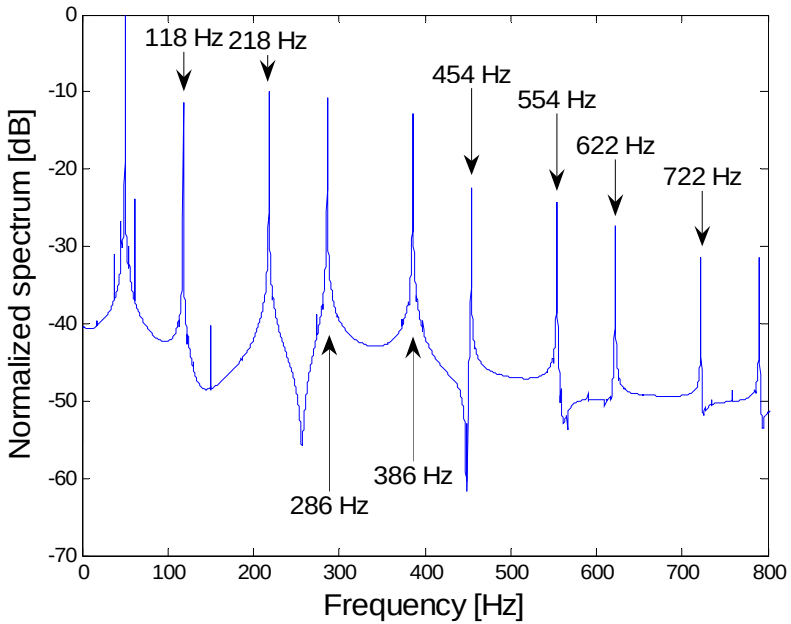


b) Predicted current spectrum

Frequency content of predicted and measured DFIG stator line current for a stator short-circuit fault

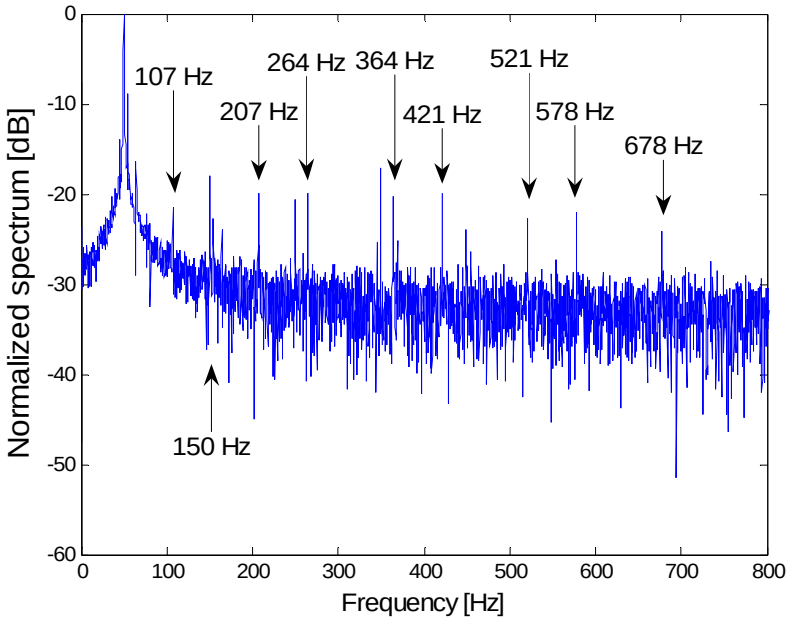


a) Experimental current spectrum

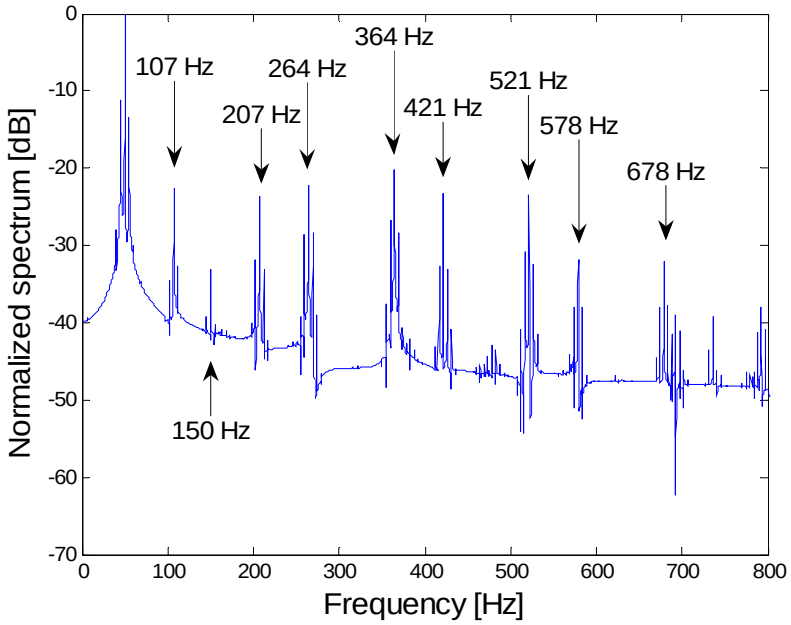


b) Predicted current spectrum

Frequency content of predicted and measured DFIG stator line current for a stator open-circuit fault



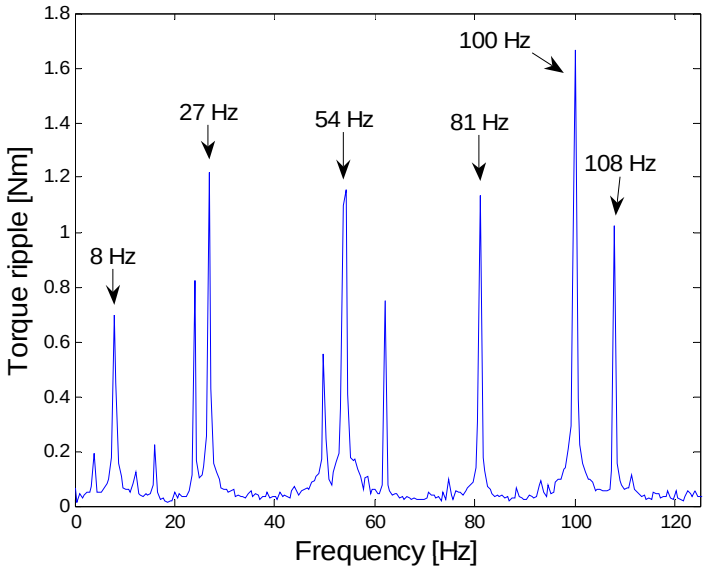
a) Experimental current spectrum



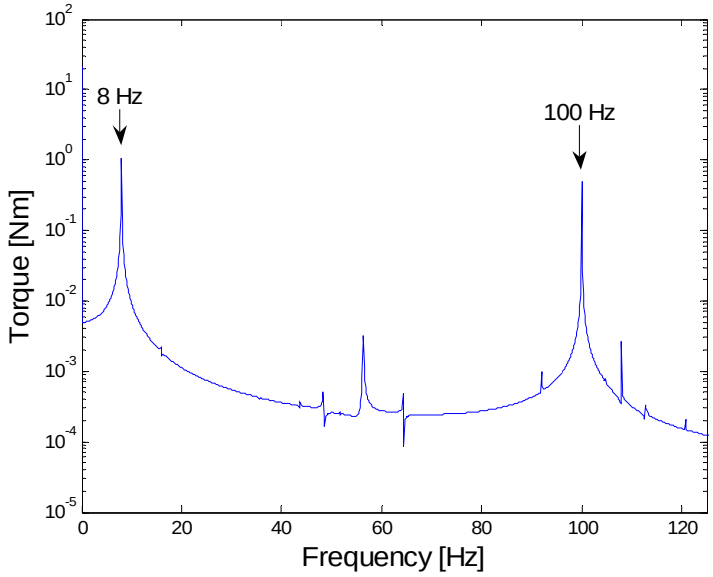
b) Predicted current spectrum

Pulsating torques and losses in DFIGs with unbalanced stator and rotor excitation

a) Measured torque ripple spectrum



b) Predicted electromagnetic torque spectrum



Calculated Total Stator and Rotor Joule Loss for Various Unbalanced Supply Operating Conditions

Stator voltage	Rotor voltage	Stator Loss [W]	Percentage increase [%]	Rotor Loss [W]	Percentage increase [%]
Balanced	Balanced	514	0	345	0
Unbalanced	Balanced	532	3.5	412	19.4
Balanced	Unbalanced	630	22.6	342	-0.9
Unbalanced	Unbalanced	656	27.6	421	22.0

Work currently under way

- The effect that rotor winding faults have on the stator current spectrum is being investigated.
- Simple analytical expressions that relate the stator current spectrum to each specific fault condition are being developed.

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What we would like to do

- Incorporate air-gap eccentricity / bearing wear in our model and verify the calculated performance on the (modified) test-rig.

  Can we detect bearing faults/wear using spectral analysis of the stator current?

- To explore how the identified steady state effects of stator and rotor winding faults are manifested when DFIG is in variable speed operation

  Will the dynamic behaviour of the turbine be a barrier to current spectral analysis?

List of publications

- S. Djurovic, S. Williamson, A. Renfrew, 'Dynamic model for doubly-fed induction generators with unbalanced excitation, both with and without winding faults', IET Electric Power Applications, March 2009.
- S. Djurovic, S. Williamson, P.J. Tavner, W. Jang, 'Condition monitoring artefacts for detecting winding faults in wind turbine DFIGs', European Wind Energy Conference and Exhibition EWEC, March 2009.
- S. Djurovic, S. Williamson, 'Losses and pulsating torques in DFIGs with unbalanced stator and rotor excitation' IEEE International Conference on Sustainable Energy Technologies ICSET, November 2008.
- S. Djurovic, S. Williamson, 'A coupled-circuit model for a DFIG operating under unbalanced conditions', IEEE International Conference on Electric Machines ICEM, September 2008.

More publications are currently under review for publication in journals/conferences.

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SUPERGEN WIND

Thank You