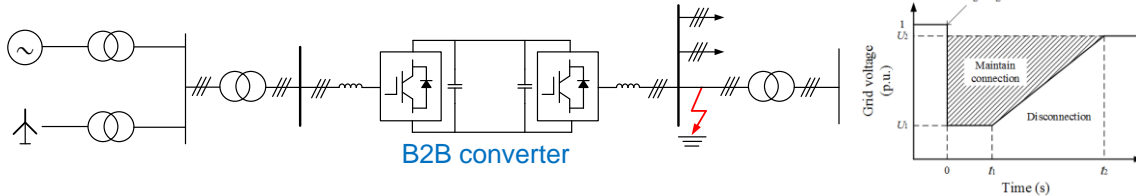


Enhancing Control Capability of ORE Systems for Stress Management and Grid Support

Prof Li Ran

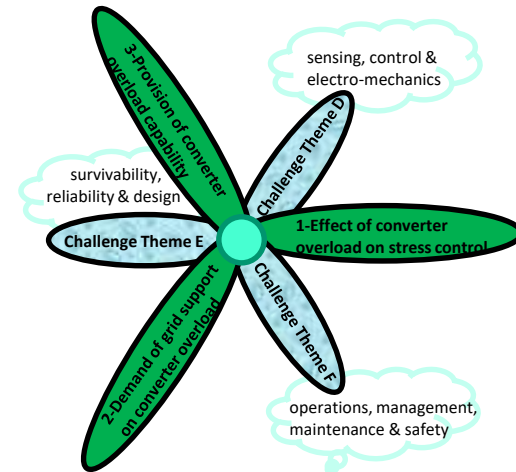
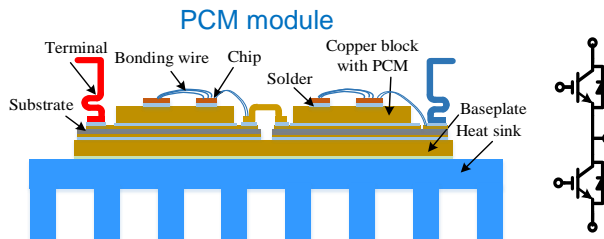
Motivation

- **Grid Support:** grid inverters are unable to source large current during grid fault.
- **Stress Management:** there is no coordinated stress management strategy.



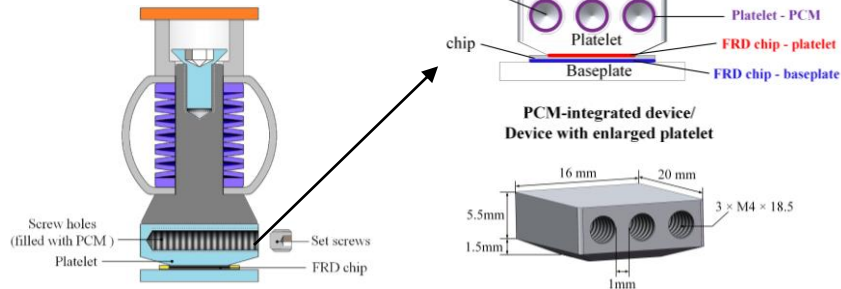
Methodology

- WP1. Model building and identification of critical scenarios.
- WP2. Optimized short term overloading in power electronic control.
- WP3. Power module design for short term overload capability.

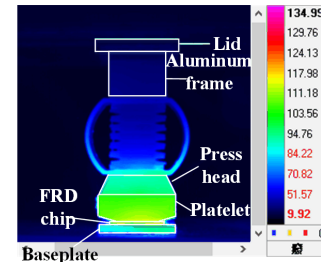


PCM integrated power module design for grid support

PCM integrated module

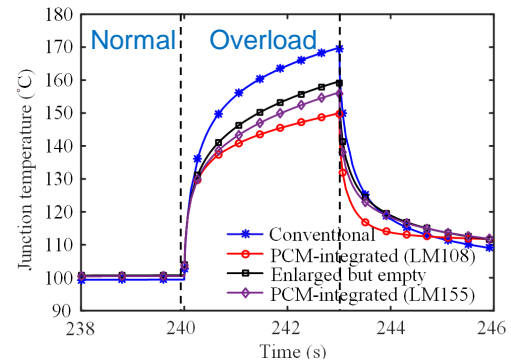


Thermograph after 2.4 p.u. overloading



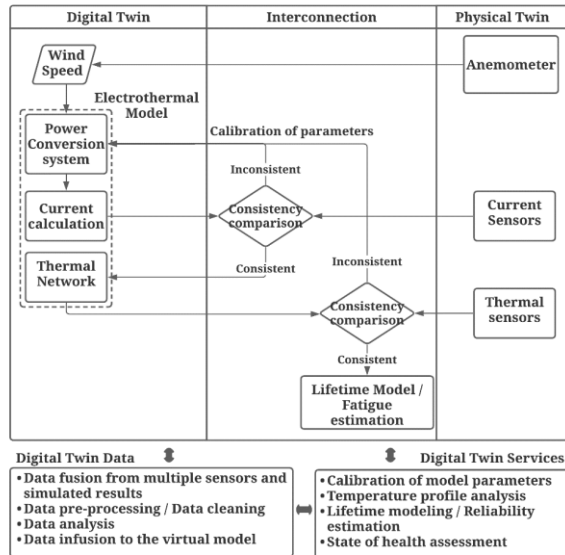
PCM-integrated device (LM108)

- Integrate phase changing material (PCM) LM108 into a customised press-pack module to enhance converter's short-term overload capability.
- The converter can be overloaded to 2.4 p.u. for 3s, whilst the junction temperature is still below 150 °C.



Stress management for wind turbine pitch system

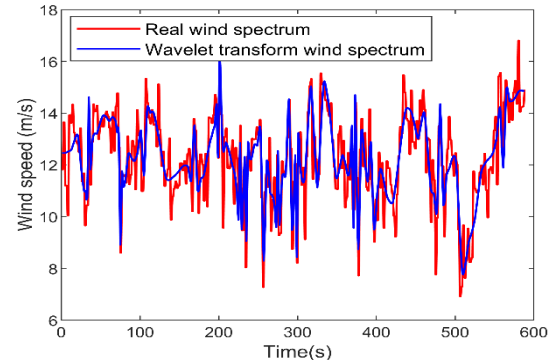
Digital twin framework



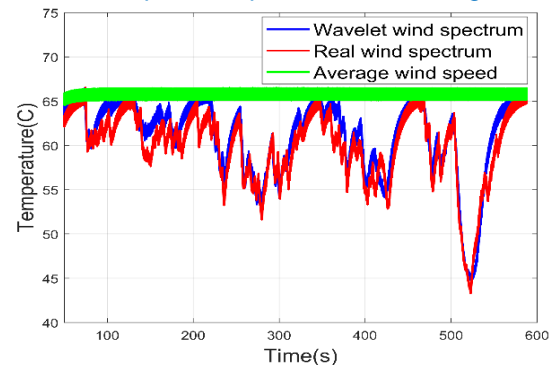
- A digital twin system is established to evaluate the electrothermal behaviour of the WT with PCM modules under high granularity wind speed data.
- Using wavelet spectrum techniques, the real-time 1-sec sampled wind data can be compressed to 10%.

Wind data reconstruction

WARWICK
UNIVERSITY

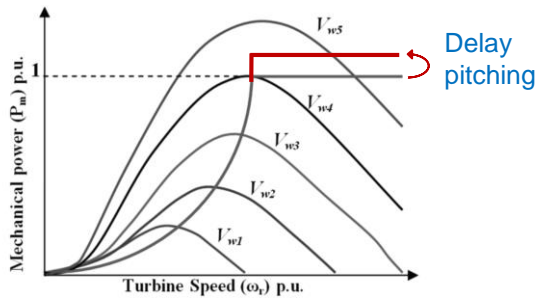


IGBT temperature profiles from the digital twin

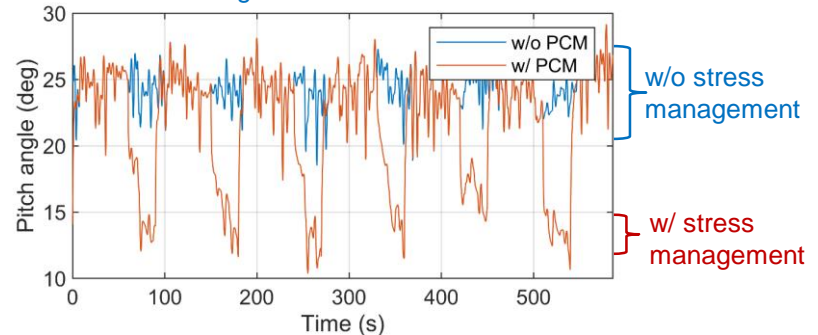


Stress management for wind turbine pitch system

Stress management strategy

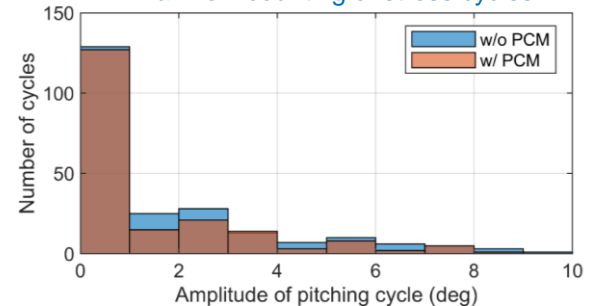


Pitching movement in 10-min



- A coordinated stress management strategy for pitching system is developed in the digital twin environment.
- To reduce pitching movements, overload the converter for 30 seconds - increase the pitching point from 12m/s to 14m/s, PCM recovers for 60s, repeatedly.
- The overall mechanical stress cycles of pitch system is reduced by 10% after implementing the proposed method.

Rainflow counting of stress cycles



Conclusion

Research outcome

- The proposed PCM integrated module can be overloaded to 240% of its rated current for 3 seconds without exceeding the maximum allowable junction temperature.
- In digital twin system, a simple on-off control strategy shows about 10% stress reduction on pitching system. Improvement of control strategy would produce more effectiveness.

Follow-on work

- Develop PCM power modules for EVs, CRRC and Dynex at Birmingham, £300K.
- Rapid response and 're-solidification' by using liquid-gas PCM, ORE Catapult, £140K EngDoc.

Appendices

- [1] Ren H., Shao W., Ran L., Hao G., Zhou L., Mawby P. and Jiang H., "A Phase Change Material Integrated Press Pack Power Module with Enhanced Overcurrent Capability for Grid Support – a Study on FRD", **IEEE Trans. on Industry Applications**, Vol. 57, No. 4, 2021, pp3956-3968
- [2] Iosifidis N., Zhong Y., Hu B., Chen B., Ran L., Lakshminarayana S., Jia C., McKeever P. and Ng C., "Reliability of Wind Turbine Power Modules Using High-Resolution Wind Data Reconstruction: a Digital Twin Concept", **IEEE ECCE Conference**, October 2021, Vancouver