

CASE STUDY:

QUADRATURE BOOSTER

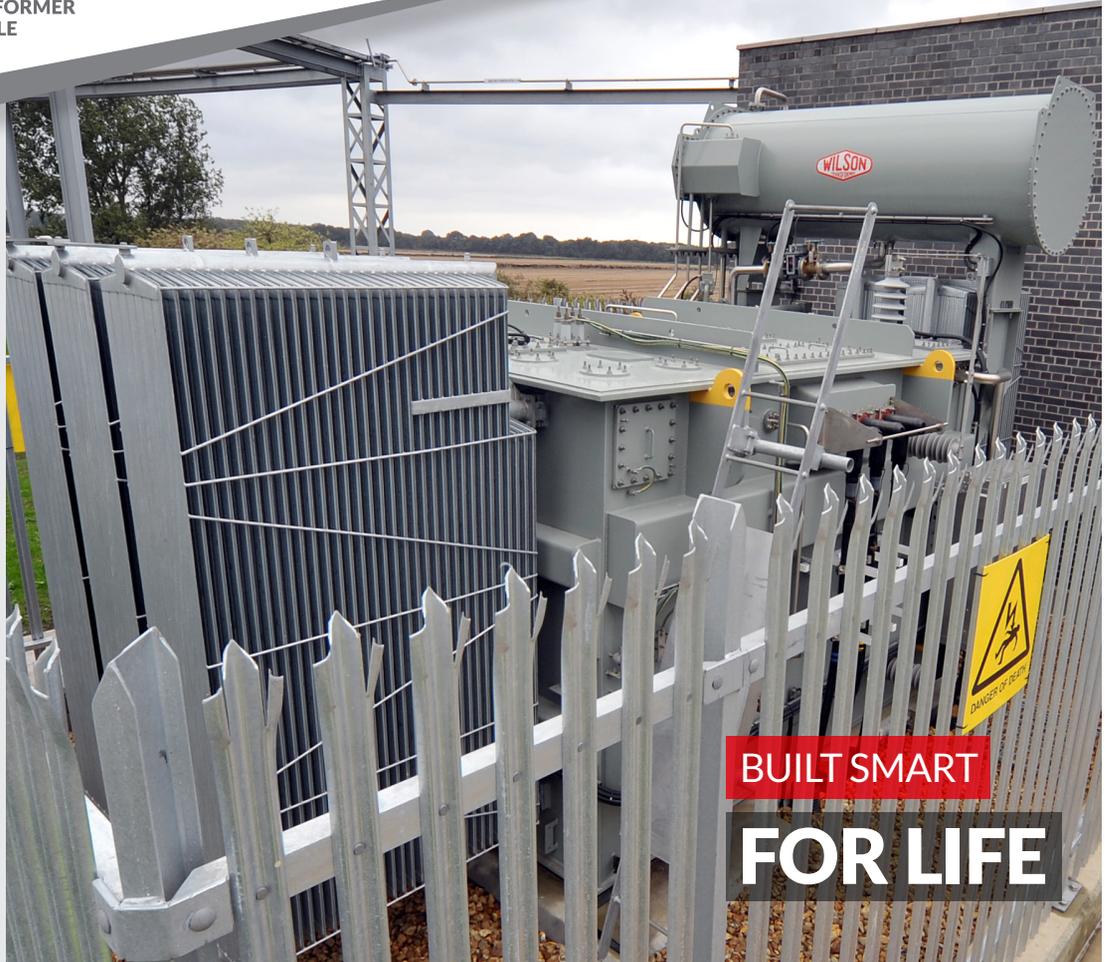
Wilson Transformer Company has manufactured and delivered a Quadrature Booster to UK Power Networks for their Flexible Plug and Play (FPP) project.



THE TRANSFORMER
PEOPLE

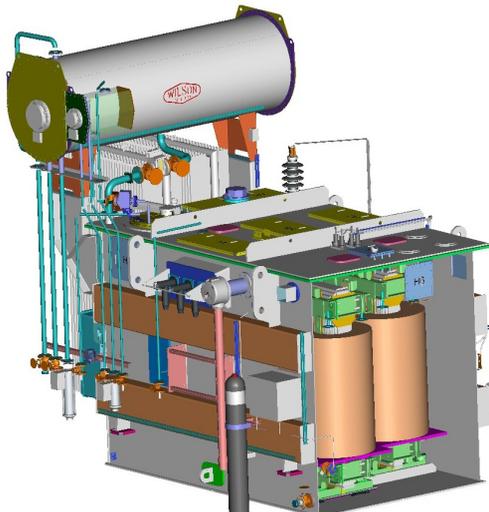
KEY FEATURES

- > Control the Flow of Real Power on 3-phase Networks
- > Ideal for Increasing Renewable Generation
- > Solution to Network Load Sharing Constraints
- > Custom Design, Test and Manufacture Capability



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Quadrature Booster (Quad Booster), also known as phase-shifting transformer (PST), is used to control the flow of real power on three-phase electricity networks. The technology is mostly used in the transmission networks where there is a capacity constraint in one or more of the parallel circuits.

Through collaboration with UK Power Networks, Fundamentals and British Sugar PLC, Wilson Transformer Company developed and manufactured the first 30MVA Quad Booster for UK Power Networks. It was installed on 33kV parallel circuits at UK Power Networks' Wissington BSP substation to overcome an existing constraint due to sub-optimal load sharing.

The Wilson Transformer Company Quadrature Booster is a smart way of managing load sharing constraints in the transmission and distribution networks.

CHALLENGE

The challenge for the project team was that there were no known Quadrature Boosters or Phase Shifting Transformers being used at this rating or voltage before. The design team in Wilson Transformer Company was able to deliver on the project requirements.

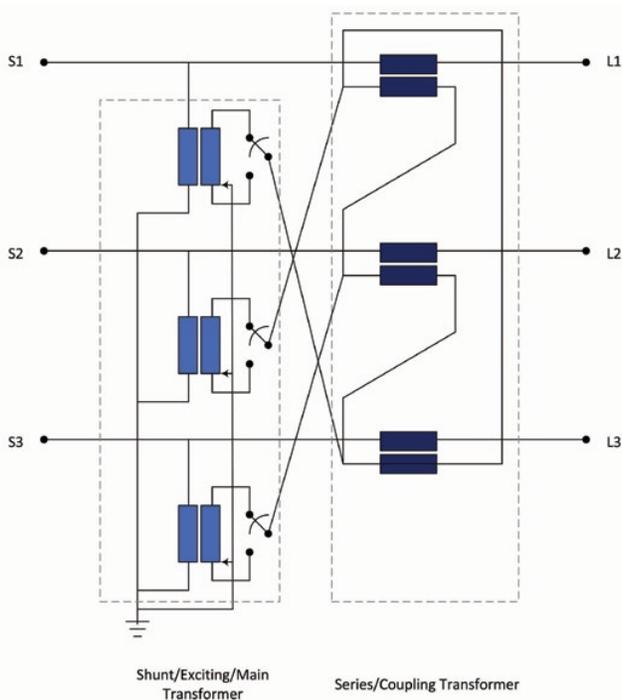
The Quad Booster was designed, manufactured and fully type tested, including lightning impulse, at Wilson Transformer Company's Glen Waverley facility in Australia. The commissioning was completed in July 2013 and resulted in improved utilisation of the existing lines which added over 10MW capacity headroom availability.

BASIC PRINCIPLE

Quad Booster technology is based on the principle that active power flow (P) through a transmission line is directly proportional to the sine of the phase angle (δ) between the source terminal voltage (VS) and load terminal voltage (VL).

$$P = |VS| \cdot |VL| \sin \delta / X_L$$

By manipulating the voltage phase angle using a Quadrature Booster, the active power flow can be controlled to remain within the constrained rating of the "weaker" circuit. The Quadrature Booster tap position, and hence the added phase angle, is chosen such that the current is shared more equitably between the parallel lines.



Connection diagram of Indirect Asymmetrical Quad Booster

A Quadrature Booster consists of two separate three-phase transformers specially connected: a shunt connected unit on the supply terminals S1/S2/S3 and a series connected unit on the load terminals L1/L2/L3. The shunt connected transformer is also called the main or exciting transformer and is fitted with an On-Load Tap Changer (OLTC). The series-connected unit is a coupling transformer.

FEATURES

The two-core design with its flexibility to control OLTC step voltage and current was adopted for UK Power Networks FPP Quad Booster project. Due to the relatively small MVA and kV rating, the Main and Series units were accommodated in the same tank. An "Asymmetric Quadrature Booster" concept was adopted as shown in connection diagram. The physical size is approximately that of a 30MVA transformer.

The windings were designed for the worst short circuit forces at the mean tap position when the main transformer offers negligible reactance. Full type testing was undertaken, including lightning impulse which was tested with the main and series transformers connected inside the tank and voltage applied in turn to the supply and load terminals. Specified phase angle shift under load was estimated based on expected percentage regulation under site power factor and load testing was carried out at unity power factor under no load.

SOLUTION TO NETWORK CONSTRAINTS

Transmission and distribution utilities are expected to reinforce or upgrade their assets to mitigate network thermal and voltage constraints and reverse power flow issues.

A Quad Booster is considered to be a smarter way of managing load sharing constraints. Wilson Transformer Company has the capability to design, test and manufacture Quad Boosters to suit these applications and networks.

CONCLUSION

Following the commissioning of the Quadrature Booster, it was clear to see from the load profiles that the circuits are now operating closer to each other due the control and load equalising effect of the Quadrature Booster. These results demonstrated that the Quadrature-booster improved the load sharing between the two lines, and that additional 10MW capacity headroom was possible which provided a key learning point of this trial. The detailed analysis is outlined in the Quadrature Booster Trial Report prepared by UK Power Networks.

Reference: Flexible Plug and Play - Close Down Report, UK Power Networks, 2015.

For information about our products please visit:
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WILSON TRANSFORMER COMPANY PTY LTD

Power Transformer Business Unit
310 Springvale Road, Glen Waverley (PO Box 5)
Vic 3150 Australia
T: +613 9560 0411
F: +613 9560 0599
E: powersales@wtc.com.au



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