

The Inverse Times

Tesla Consultants

Specialist Consultants to the Electric Power Industry



October 2017

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From our Managing Director



The first half of 2017 was another busy period for all of us here at Tesla. Last month we saw David Harris stand down as a member of our Board of Directors after 6 years service. I would like to thank David for his invaluable commitment and contribution to the Board. David is a senior member of our Protection team, and will continue to focus on highly specialist client deliverables and mentor our younger engineers. Our AGM in August saw the election of David Collins to the vacant seat on the Board of Directors and we welcome him to the role.

Recent technically challenging projects undertaken include Battery Substation protection and control, designing special protection schemes that allow clients to run their networks to significantly closer tolerances, rolling out designs for very large IP based substation control systems, and providing entire project engineering overview for new Geothermal Power Stations. Tesla's speciality is having diverse teams of highly skilled engineers. With our higher ratio of senior staff working together across Generation, Substations, Control, Communications and Protection we provide innovative solutions by drawing on more than one skill set.

If you see anything in this newsletter you would like to discuss further, please drop me an email, call; or contact any of our staff directly.

Alan Wallace

220kV Bus Zone Protection at Twizel Substation

Earlier this year a new duplicate bus zone protection scheme at Twizel substation was successfully commissioned. Tesla was engaged to complete the Detailed Design for this programme of works which replaced the existing 220 kV bus zone and CB fail protection scheme with a duplicate BZ scheme (with no check zones).

Tesla has successfully undertaken many line and transformer protection upgrades, so has a very good understanding of the design effort required to undertake these tasks efficiently. There were four significant

complexities to this project: the breaker and a half bus arrangement at Twizel, the three-terminal line protection, the hard-wired interlocking scheme and the integration of the SMS concurrently with the other works.

Commissioning required careful planning. Due to the 140 sequential outages required on both primary and secondary equipment and considering the potential disruption to the Grid, that planning becomes critical - a good reason for our design to carefully look at proposed project phasing and construction sequences.



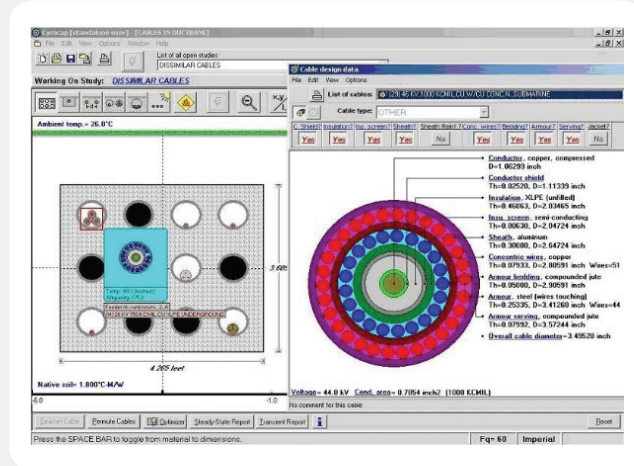
Software Systems, Design Automation & Design Tools

Tesla owns and operates a wide range of equipment, hardware and software to support our professional services. These include:

- CDEGS[®] software, earthing studies
- An "unlimited busses" license for the DigSilent PowerFactory[™] load flow/fault study software.
- CYMCAP cable rating software for installation design and specification of power cables
- Pathloss 5 radio path analysis software
- Map Toaster (NZ topographical maps) for radio path analysis
- AutoCAD including 3D modelling.
- Raster Design (which is required to amend raster drawings).
- CAD Overlay.
- Protection relay manufacturer proprietary software

There are quite a few aspects of power systems design that can be repetitive or require complex calculation. Tesla has been building up a library of **in-house tools** over the years that provide a level of automation. Once these tools are meticulously tested and proven they can provide significant efficiencies and improve the quality of deliverables to our clients. Some specific examples are:

- Seismic analysis (high-level checking tool)
- Engineering and draughting resource management tool
- Tool to automate data entry into a DigSilent StationWare repository
- Protection relay setting tools to automatically create relay setting files once raw settings have been calculated
- Electromagnetic Radiation assessment tool
- Fibre Loss calculation tool



- Telecommunications DC Design tool
- Overcurrent/earth fault protection calculation and discrimination graphing tool
- Auto-transformer impedance calculation tool
- Protection relay directional decision tools
- Numerous other customised tools developed in-house to improve design efficiency and minimise errors

Tesla takes advantage of a number of in-house **draughting scripts** to improve efficiency and accuracy of drawing production, including a significantly customised AutoCAD system the uses the AutoCAD scripting language, LISP. These scripts, along with other custom in-house tools, allow our draughting team to populate drawing sets from standard design templates quickly and without error. We are also able to extract cable information from drawings to allow a cross-check of ferrules and cable core spares, further reducing the possibility of error.

For further information on this project, contact Geoff Torr
geoff.torr@tesla.co.nz

Application of Synchrophasor-Based Autoreclose Synchronism Check

A paper discussing a novel autoreclose synchronism (synch) check scheme utilising synchrophasors (SP), co-authored by Pieter van Dyk of Tesla Consultants and David Chen of Transpower, was presented at the CIGRE 2017 event the South-East Asia Protection, Automation and Control Conference (SEAPAC 17) in March 2017.

Traditional synch check schemes use the primary power system to communicate information about bus voltages and their angle between the two line-ends. Line voltage transformers (VTs) are required to receive this information at both ends of the circuit so that the voltage on the line can be compared with the local bus voltage.

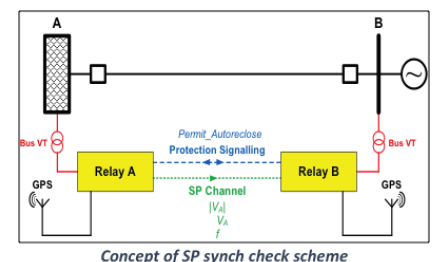
Typically, Transpower 110 kV substations are provided with bus VTs but not line VTs. When synch check is required,

the installation of line VTs may extend the substation boundary and incur significant costs.

A modern secondary solution can leverage existing communications infrastructure to provide a lower cost communications channel using SP.

SP can be used to transport time-stamped voltage information (phase, magnitude and frequency) between line ends to allow a local relay to determine whether an in-synch condition exists. This allows synch check to be implemented without line VTs, provided suitable logic and functionality are available within the protection relay.

The paper proposes an example implementation using modern numerical relays. A functional description of scheme operation, limitations and failure modes is also discussed.



Tesla Consultants has since developed a Transpower standard guide to provide guidance to designers and technicians, responsible for modifying protection relay settings. This details how to implement an SP based auto-reclose synchronism check scheme on various combinations of Transpower's approved SEL400 series relays.

For further information please contact
pieter.vandyk@tesla.co.nz



Equipment Specifications for High X/R Ratio Situations

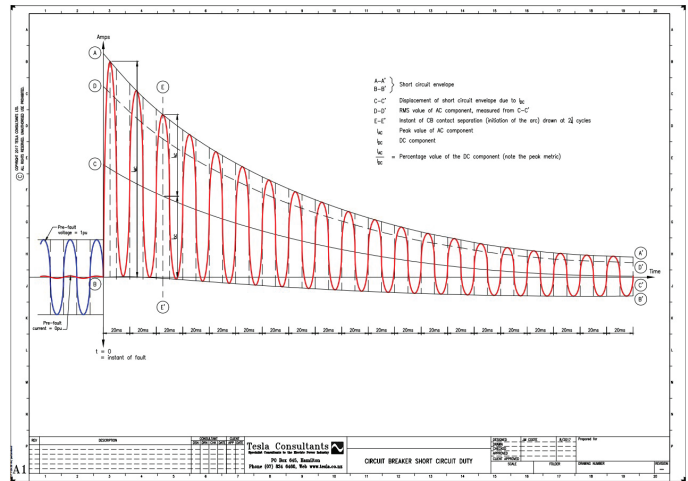


If you're reading this on a Wednesday, there's a good chance Tesla's Jeremy Coote will be making a technical presentation to his colleagues in the Hamilton office. Jeremy has been passing-on his power-systems generation experience to the younger generation of

Tesla engineers by presenting on a range of varied and interesting, yet sometimes misunderstood subjects.

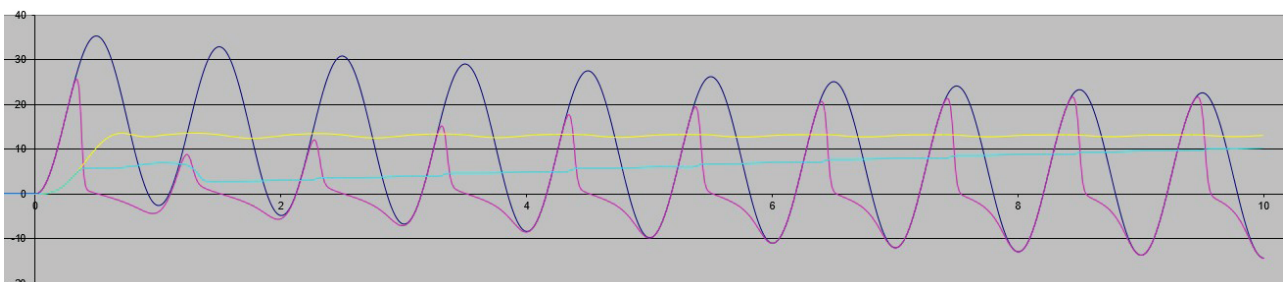
While the presentations have mostly related to Power Station applications (as follows), an overriding theme which extends to Distribution networks is the complexities or traps of designing for the high system X/R ratio which exists near a Power Station (e.g. CB and CT specifications as outlined further below);

- **Stator earth-faults;**
 - limiting these to low current values within stator core-lamination 'burn-limits' viz high-resistance earthing
 - getting the resistance earthing 'just right'; to avoid capacitive transient-overvoltage hazards/failures
 - practical sizing of high-resistance earthing transformers/resistors to achieve optimal earth-fault limitation
- **Round rotor (2-pole) generators vs Salient rotor (multi-pole) generators**
 - basic construction differences
 - differences in steady-state-stability-limit (SSSL)
 - development of generator capability diagrams
- **Generator short-circuit envelope**
 - the AC component which decays over time based on the generator time-constants
 - the DC component which decays over time based on the system X/R ratio, and why it must exist in an inductive circuit
 - differences between generator saturated & unsaturated reactances, and using the correct ones in fault-studies
- **Difficulties with high X/R ratio and associated DC component near Power Stations**
 - why the DC component of fault current is higher near generation sources
 - why the DC component of fault current is more onerous than the AC component in terms of CB and CT ratings



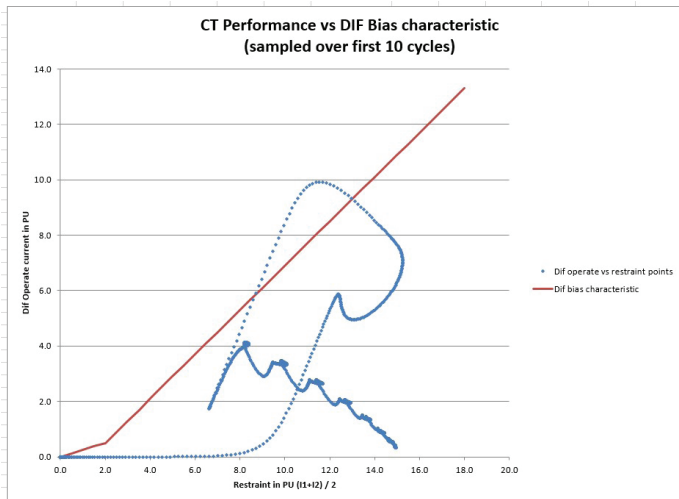
Above - extract from presentation note on sizing CBs based on the AC + DC components in aggregate

- Specifying CBs for the DC component in high X/R ratio networks
 - why the DC component of fault current is onerous in terms of CB make/break duty rating
 - practical sizing examples for CBs based on the AC + DC components in aggregate
 - explaining the concept of 'allowable % DC component rating' in CB equipment specifications
 - examples where CBs specified to a distribution class, would be unsuitable near a Power Station with high X/R ratio
- Specifying CTs for the DC component in high X/R ratio networks
 - why the DC component of fault current is onerous in terms of CT rating
 - why the DC component of fault current causes CTs to saturate more severely than the AC component
 - how CT saturation affects protection performance based on protection-type, i.e. operation with certainty for in-zone faults vs non-operation with certainty for out-of-zone faults
 - tips and tricks for practical CT sizing in high X/R ratio networks; i.e. getting the balance 'just right' between meeting protection requirements vs specifying a practical-manufacturable CT
 - desktop analysis of CT saturation compared against a biased-differential relay characteristic, i.e. checking for non-operation with certainty for out-of-zone faults



Above, Extract from presentation notes on sizing CTs; actual CT saturation vs an 'ideal' CT, $X/R=40$

Equipment Specifications for High X/R Ratio Situations - cont



Jeremy tells us he's preparing notes for the next presentation, but won't yet spill the beans on the subject matter. He says, "It'll surprise a few people, it is often misunderstood by electrical engineers, but it relates to the most common electrical-question I get asked by mechanical engineers". Sounds intriguing; we suspect it might be on 'Reactive Power' but will just have to wait and see.

If any aspects of these presentations are applicable to your organisation or any of your upcoming projects, then please feel free to contact Tesla to discuss further.

Left - extract from presentation notes on sizing CTs; transformer-differential protection vs CT saturation for out-zone fault, X/R=22, showing differential tripping in error

Managing Fibre Optic Cable and Patching Records



Tesla has provided an on-going Fibre Optic termination and patching record management service for a major client since 2011.

This service arose when our client realised that when undertaking multiple projects, multiple changes to fibre build and records are often also required. This can result in detail being

over-written or not recorded in the site records that are used for maintenance or future projects.

To resolve this, all records of the client's fibre terminals and patch cabinets from their records management have been issued permanently to Tesla. This ensures other parties cannot accidentally overwrite site records, enforcing one party maintaining the correct records with inputs from many projects.

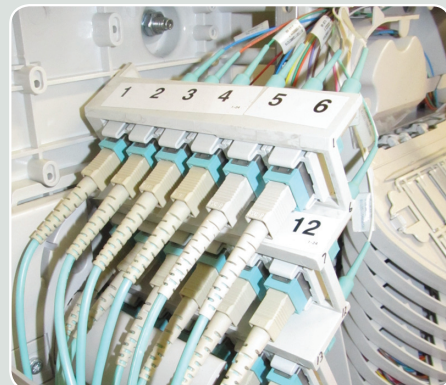
Judy Love, from our Draughting Team, leads this role, responding promptly to designers and contractors with drawings showing reservations for work they have defined, receiving their mark-ups and updating the formal record for publishing on the client's records management systems promptly.

The service we provide is greater than a document management process. Judy is familiar with the client's approved fibre design standards, so can provide advice

when needed, and undertakes a review to ensure the returned updates cross-check correctly with the remaining site records.

This is an area of rapid change, and sadly some site works still occur without following any recording process, so Tesla's engagement includes a small number of spot site audits each year. This information, plus an arrangement whereby contractors are encouraged to send photographs of cabinets, patches, and labels to Tesla whenever they have an opportunity, allows Judy and the team to update site records in the background between formal project works.

Fibre Optic cabling and patching is expanding rapidly within the electrical industry, with a high degree of routine change leaving the opportunity for site records to become quickly out-dated. If this problem is familiar to you, feel free to call John Wraight, Tesla's Draughting Manager to discuss ways Tesla could provide a service that assists your record keeping. Email John at john.wraight@tesla.co.nz or phone him on 07 834 6473.



Keeping it Simple



What is a recloser? In electric power distribution, a **recloser**, or **auto recloser**, is a circuit breaker equipped with a mechanism that can automatically close the breaker after it has been opened due to a fault. Auto Reclosers are used on

overhead distribution systems to detect and interrupt momentary faults. Since many short-circuits on overhead lines clear themselves, after deenergisation, a recloser improves service continuity by automatically restoring power to the line after a momentary fault.

The Recloser is essentially a self-contained device with the necessary intelligence to sense overcurrent's to time and interrupt fault currents, and to re-energize the line by reclosing automatically. If a fault is permanent, the recloser locks open after a preset number of operations (usually three or four), isolating the faulted section from the system upstream.

Tesla have been engaged by several lines companies over the years to produce standard recloser settings templates to optimise the reliability of these reclosers. For more information contact chris.ohalloran@tesla.co.nz

Annual Fishing Trip



Tesla's 2017 annual fishing trip was the 10th Anniversary trip and the first trip without Richard Moore, who passed away last year. A toast to Richard with a drop of port to share fond memories was held before the fishing started.

Earlier on it had been doubtful the trip would go ahead with a storm causing closure of the Thames Coast road to Coromandel. As resilient as ever the crew took the longer "scenic" route via Whitianga, ensuring the trip went ahead. Despite a strong wind in the morning, the day turned out fine with relatively calm seas. Fish numbers were down, but it was still an enjoyable day. Witnessing a mussel barge harvesting was a new experience.

Fisherman are a very superstitious lot. Spend more than a few days aboard a fishing boat and you start to understand the feelings

of "luck" that come with good streaks and slumps of slow fishing, and everything in between. There are two very long-standing superstitions aboard boats that have been passed down to fisherman of all kinds. Namely – never bring a banana or a suitcase aboard a fishing boat.

Tell that to Graeme Hope. After eating a banana on board he reeled in the biggest Snapper of the day (2.27kg) and now has his name etched on the fishing trophy for 2017.



Introducing New Staff



**Russell
Cathcart**

Russell joined Tesla Consultants in July after working for 11.5 years for Aurecon. Russell has worked extensively within the power generation, transmission and distribution fields. He is a primary design engineer with good project management experience, having worked on a very broad range of projects and voltages including: HV grid connections and substations, MV plant reticulation and LV plant auxiliaries.



**Sam
Viskovic**

Joining Tesla Consultants in September, Sam has 12 years industry experience. He is a secondary systems design engineer and has been responsible for projects to a variety of clients in the generation and distribution sectors of NZ and overseas.

Sam is a user of DigSILENT and has experience designing transformer voltage regulation, arc flash protection, fast bus and various differential protection schemes for PowerCo, Vector and other lines companies in NZ.



**Rob
Walker**

Commencing his career with NZ Electricity as a draughtsman producing electrical, mechanical, civil and communications drawings within the generation and distribution industry, Rob quickly moved to a Power Systems Technician role. Rob is our newest recruit, joining our Communications team in October. Rob's depth of experience includes the development of SMS migration plans and other related processes as well as the installation, configuration, maintenance and fault diagnosis of PLC, RTU and SCADA equipment.

Recognising Service

Recently presented with Distinguished Service certificates were Tim Crawley (20 Years) and Daniel Han (10 Years). Congratulations to both and thank you for your valued commitment to Tesla Consultants.



Tim Crawley



Daniel Han

Board of Directors



Alan Wallace
Managing Director

☎ 07 834 6475
Email: alan.wallace@tesla.co.nz



Geoff Torr
IT Manager/Design Engineer

☎ 07 834 6464
Email: geoff.torr@tesla.co.nz



Tim Crawley
Consulting Engineer

☎ 04 913 4167
Email: tim.crawley@tesla.co.nz



David Collins
Consulting Engineer

☎ 03 968 4809
Email: david.collins@tesla.co.nz



Matthew Hall
Consulting Engineer

☎ 03 940 7101
Email: matthew.hall@tesla.co.nz

Contact us

Hamilton

Contact: Alan Wallace
Phone: 07 834 6475
Email: alan.wallace@tesla.co.nz

Auckland

Contact: Jeremy Coote
Phone: 09 425 6003
Email: jeremy.coote@tesla.co.nz

Wellington

Contact: Tim Crawley
Phone: 04 913 4167
Email: tim.crawley@tesla.co.nz

Christchurch

Contact: David Collins
Phone: 03 968 4809
Email: david.collins@tesla.co.nz

Tesla Consultants is an engineering consultancy providing specialist engineering and related services to the electric power industry.

