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WHITE PAPER

Real Time Thermal Rating (RTTR) for Power Transmission Cables – What is state of the art?

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Introduction

This article discusses the evolution of Distributed Temperature Sensing (DTS) and Real Time Thermal Rating (RTTR), where we are today, its uses, benefits and how the operators are implementing this technology.

DTS technologies have been used for the rating of power cables since the 90's. In 1998 a power cable failure in Auckland shut down the city's central business district and it was found that better information on the thermal behaviour of critical circuits might have avoided the catastrophic electricity supply failure of the CBD1. This incident shone a light on areas for improvements in terms of designing power systems, redundancy requirements and cable ratings in particular. This brought DTS and RTTR to the forefront and was one of the catalysts for the rise of the role of DTS and RTTR in thermal cable rating.

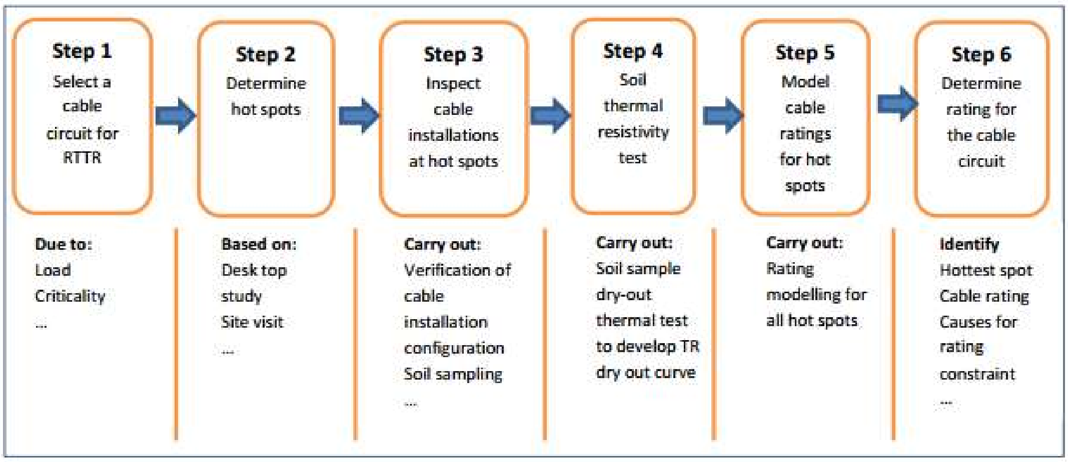
What are the principles and benefits of a Real Time Thermal Rating system?

Real Time Thermal Rating is a methodology to assess operational thermal rating of equipment such as underground cables, overhead lines and transformers using real-time data of environment conditions and loading rather than conservative assumptions. RTTR could provide further information on thermal headroom; indicating whether areas are stressed (overheated) or in fact have more capacity than originally anticipated.

The temperature of an asset itself is key for RTTR as this should not increase above its design limits. Where a Distributed Temperature Sensing (DTS) system is installed, the equipment or asset can be measured continuously. Alternatively, where a DTS system is not available, it can be estimated based on installation condition information and load data for assets.

RTTRs for underground cables with DTS can use direct measurements of the cable temperature, RTTR for underground cables without DTS must use environmental measurement, sheath temperature and loading and will be inherently more conservative thus losing some of the key benefits of using online data.
RTTR technology can be effectively applied within a proactive, preventative maintenance strategy which provides the following benefits:

- Defer costly upgrades
- Increase the yield of distributed generation
- Identification of potential thermal bottlenecks / pinch points
- Support the network during outages



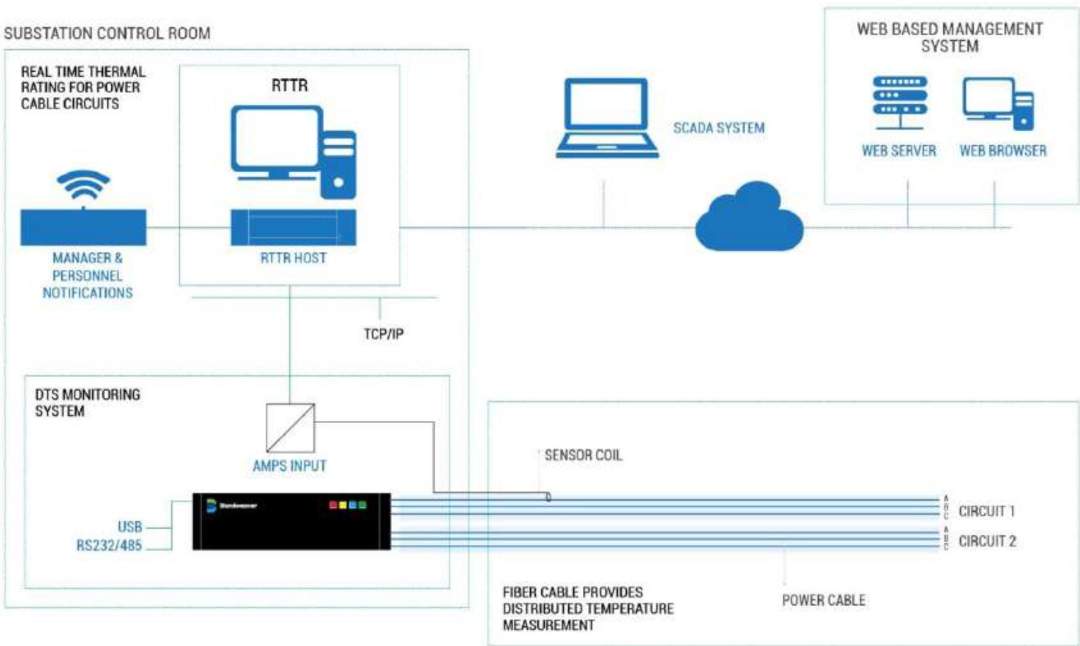
RTTR process overview

More information and details can be found in the Customer Led Network Revolution - Lessons Learned Report Real Time Thermal Rating [2].

How is RTTR implemented?

Wherever possible RTTR is combined with online temperature and current measurements to provide a dynamic cable rating which allows the operator to react and adjust according to the specific cable environments. Fiber optic Distributed Temperature Sensors (DTS) are ideal for this application as it provides a continuous temperature profile along the entire length of the power cable.

Below is a schematic of a typical RTTR configuration for an underground cable:



What thermal modelling algorithms are used for RTTR?

Typically RTTR thermal models are based on either the IEC Standards 60287/60853 and/or on a finite element method (FEM), a numerical technique for finding approximate solutions to boundary value problems for partial differential equations. The method chosen depends on a number of factors including the type of installation - more complex cases (crossing of cables, short length, pipe etc.) typically utilize FEM based models which require a greater understanding by the user and higher computational abilities. However, most RTTR thermal models use an approach based on the IEC standards.

Comparative analysis indicates that IEC type thermal models compare favorably with FEM in the right environment[3]. Methodologies vary and can be dependent on the available data and sophistication of models from region to region. For example, research published by Durham University[4] shows the differences in methodologies between overhead cable projects in the US and the UK, with the US having more sophisticated weather modelling and the UK having better uncertainty modelling.

Experience from operators from the late 90's through to today

Even by 1999 and following the Auckland incident operators recognized that the technology brought significant benefits and started to incorporate fiber optic sensing into their operations. In this early stage it was clear that there was more manual intervention required, compared to today, as the data was monitored and analyzed by an engineer[5].

Since the late1990s there has been widespread adoption of RTTR by utility operators. For example in recent years BC Hydro was able to show how DTS monitoring produced higher cable ratings[6] by 2008 and in 2013 Transpower – New Zealand, one of the most proactive of operators, used DTS and RTTR as a key part of their preventative maintenance strategy[7]. OFGEM- SP Energy Networks has demonstrated the usefulness of temperature monitoring of windfarm cables[8] and how it can be used to monitor capacity and the potential to increase ratings.

Power operators across the sector are incorporating RTTR and DTS into their processes in a variety of ways. As the technology, methodologies, mathematical and computer modelling evolves it is highly likely that the data provided by these system will enable the sector to work more efficiently, and productively.

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   This paper shows a comparison in results of FEM vs the IEC type thermal models and shows that it provides satisfactory results in the right environment.
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About Kifta Technologies

Kifta has been providing advanced fiber optic monitoring sensors and integrated technologies since 2015. Their technology portfolio covers a wide range of sensors including distributed Temperature Sensors (DTS) and Distributed Acoustic Sensors (DAS) and integrated smart intelligent software solutions. Within the Power and Utilities sectors, Kifta's distributed fiber optic acoustic and temperature sensing systems provide the operator with real time critical information on their network. This assists in reducing planned and unplanned maintenance and avoiding catastrophic failure along with managing risk effectively.