HYBRID HIGH CAPACITY TRANSMISSION CIRCUITS – CHALLENGES FOR XLPE CABLES IN SERIES WITH EHV OVERHEAD LINES

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ABSTRACT

Transmission utilities cannot always construct lines entirely overhead for the route length due to restrictions and obstructions in the right of way. Hybrid transmission lines are required to address these restrictions by installation of underground section(s) in series with the overhead line section(s). This paper outlines the various design challenges associated with hybrid feeders. In particular, a detailed discussion is undertaken around maximising the ratings for underground EHV cables, and equating these ratings to overhead line sections. A discussion of design, construction and maintenance aspects for transitioning between overhead and underground EHV lines is also undertaken. Examples are provided via a recently constructed 275 kV hybrid transmission line by Powerlink Queensland, the transmission utility in Queensland, Australia.

KEYWORDS

Hybrid transmission circuits, overhead line to cable transition, cable ratings, overhead line ratings, AC resistance measurement

INTRODUCTION

Powerlink Queensland is the Government owned corporation that designs, builds, owns, operates and maintains the transmission network in Queensland, Australia. In 2009, Powerlink Queensland constructed a nine kilometre 275 kV *hybrid* transmission line from its South Pine substation to Sandgate in the northern suburban area of Brisbane, Australia.

Fig. 1: The South Pine – Sandgate 275 kV Cable Corridor

The context of *hybrid* transmission circuits in this paper refers to circuits that are constructed as series connected sections of overhead line and underground cable. The cost differential between EHV overhead transmission line construction, versus an underground cable alternative is an important consideration that must take into account the overall planning, design, installation, operation and maintenance cost for both alternatives.

This paper shall discuss the following design and installation considerations for hybrid transmission circuits, with particular emphasis in areas listed below for the design and installation approach taken for the double circuit 275 kV South Pine to Sandgate hybrid transmission line case study:

- Equating underground cable ratings to overhead line ratings to nominate a cable system design that provides an adequate thermal capacity for the hybrid transmission circuit;
- Introducing and addressing technical challenges associated with the use of large cross section XLPE cable;
- Calculation of underground cable ratings for trench arrangements using both IEC approaches and finite element methods for non-standard trench arrangements;
- Design, testing and research considerations that can be adopted to increase confidence in long term reliable performance for highly utilised assets;
- Design, construction and maintenance considerations for the overhead to underground transition facilities.

BACKGROUND

Obtaining rights of way and easements for overhead EHV transmission lines continues to present challenges for utilities. Simple economic analysis dictates that where possible, an overhead EHV transmission line is constructed in preference to an equivalent rated EHV underground circuit due to the significant cost multipliers involved putting circuits underground at EHV voltage levels.

However, utilities are sometimes unable to completely construct new transmission circuits overhead between substation terminals. Common restrictions in Queensland that prevent completely overhead circuits include:

- Transmission corridors where some sections have existing land use which is not compatible with an overhead line and development that does not permit a wide enough corridor for new overhead construction.
- Crossing of other natural obstructions such as large waterways, where the use of overhead structures is difficult.
- Efficient use of established overhead corridors, but