ABSTRACT

Long transmission lines have a large series inductive reactance (much greater than resistance) that consumes a substantial amount of reactive power when transferring real power. The reactive power deficit results in angular and voltage stability problems that limit the flow of real power. To reduce the real power flow restrictions, the series inductive reactance of long lines must be reduced. The conventional method used to increase the stability and voltage limits on long lines is to add series capacitors. However due to the increase in servitude acquisition difficulties, statutory requirements and environmental considerations, Eskom is exploring other methods to increase power transfer on both new and existing Main Transmission System (MTS) assets without using series compensation.

The pursuit for cost effective methods to counter voltage collapse and stability problems has led to the consideration to use HSIL methods instead of series capacitors on long transmission lines in Eskom. Series capacitors are self-regulating devices that increase the production of reactive power as the real power transferred on the line increases, thus series capacitors reduce reactive power consumption, control voltage and improve the system stability. Series capacitors achieve this by reducing the line's series inductive reactance and the electrical length. The same concept applies when High Surge Impedance Loading (HSIL) methods are implemented (the series inductive reactance is reduced). Series capacitors perform this function effectively and efficiently. However, since they are additional elements on the line, they have a number of disadvantages: substantial increase in the investment costs (expensive), extra maintenance, reduction in network reliability (planned and unplanned outages), sub-synchronous resonance and complex protection settings. All these disadvantages can be removed if HSIL line design methods are found to be comparable with the installation of series compensation on long transmission lines. Added benefits to eliminating the series capacitor bank are the reduced environmental impact and an improvement in the system reliability since outages related to maintenance of the series capacitor bank will be eliminated.

The results show that HSIL methods do increase the Surge Impedance Loading (SIL) of transmission lines. The increase in SIL is achieved by altering the line's configuration which in turn alters the R, X and B values. When evaluating what HSIL methods achieve in terms of reducing the series inductive reactance which is the same objective that is achieved by installing series capacitors, the results indicate that HSIL lines are a viable alternative to installing series capacitors on conventional lines. When the conventional 3 x Tern horizontal configuration is compared with the proposed delta HSIL configuration that utilizes 4 x Tern (Increasing the number of sub-conductors in the bundle – method 2) with 12 m as the phase-to-phase spacing (compacting the phases – method 1) and 1 500 mm as the sub-conductor spacing (expanding the bundle – method 3), the series inductive reactance is reduced by 26.56% and the SIL is increased by 36.20%. When the existing perfect inverted delta HSIL tower (528A) is optimized the resulting configuration is a 4 x IEC 450 sub-conductor bundle with 740 mm as the

sub-conductor spacing where the series inductive reactance is reduced by 26.91% and the SIL is increased by 35.88%. Both these configurations clearly prove that HSIL methods are a workable alternative to the installation of series capacitors. The elimination of the series capacitor bank is network specific. Additionally, HSIL methods are effective for impedance matching to improve load sharing in parallel lines.