



EFFICIENCY OF POWER TRANSMISSION LINES WITH INCREASED SURGE IMPEDANCE LOADING (ISIL) IN LONG DISTANCE ENERGY TRANSFER

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AC overhead lines are widely used throughout the world as the cheapest and most reliable means of electrical energy transmission. Nevertheless traditional design limits the transfer distance and/or capacity of such lines, decreases their economic efficiency, and requires artificial means to increase transfer distance and/or capacity. Among widely used artificial means are series capacitive compensation of the inductive reactance of lines, SVC's, and so forth. But such means are very costly and they create serious difficulties for the operation of electrical systems.

We propose increasing overhead-line transfer distance and/or capacity by means of a very simple change of structure by employing some new rules for overhead-line design, as follows:

1. An ISIL line, as a rule, employs a number of subconductors in each of its phases: the greater the transmitted power or length of line, the greater the number of subconductors required.
2. It is necessary to place all subconductors in split phases so as to provide the maximum permissible field strength in each subconductor. It is possible to place all the subconductors of a phase in a circle with non-equal subspace distances.
3. Phase dimensions increase undesirably when the number of subconductors increase. To minimize phase dimensions, subconductor placement can be decreased in the following ways:
 - by modifying the tower structure to exclude the tower's grounded elements from the interphase space;
 - by finding optimum phase dispositions within the space;
 - by allowing larger interphase overvoltage limitations to decrease interphase air gaps;
 - by using interphase insulation spacers to decrease wind-induced interphase distance changes.

The aforementioned rules were shown to work in the field by designing and constructing the following overhead lines with *increased surge impedance loading*:

- 220 kV line of about 30 km with four subconductors per phase in China;
- 220 kV line of about 150 km with two subconductors per phase in Russia;
- 330 kV line of about 150 km with four subconductors per phase in Russia;
- 500 kV line of about 750 km with four subconductors per phase in Brazil;

- 500 kV line of about 83 km with six subconductors per phase in China;
- 500 kV lineS of about 500 km with six subconductors per phase in Russia (projected).

Such a new structure does not require any significantly new method of line construction. Conventional subconductors, insulators, and fittings may be used. Only the number of subconductors and their disposition in space, and the tower structure are unusual. Otherwise all elements are practically the same.

Use of this new type of line provides significant economic advantages in comparison with conventional lines, because inductive reactance and surge impedance decrease in nearly inverse proportion to the number of subconductors per phase. Besides the dimensions, the tower mass and width of the line right-of-way decrease also. For example, in a 220 kV line with three subconductors per phase, it is possible to obtain inductive reactance of 0.15 to 0.17 Ohm/km instead of 0.4 Ohm/km for a standard 50 Hz line. For a 500 kV line with 6 or 7 subconductors, inductive reactance can be lowered by half, in comparison with the usual lines.

Lowering the inductive reactance of long distance transmission lines in this manner facilitates a decrease in the power angle between the line terminals and ensures steady-state stability requirements without series capacitive compensation.

When the power load becomes lower than the surge impedance loading of the line, long-line reactive power and voltage can very efficiently be managed by means of magnetically controlled shunt reactors, which have been developed and manufactured in Russia.

Investigations in increased surge impedance loading of overhead AC lines are being carried out by the Saint Petersburg State Technical University (Russia) under the author and Prof. George N. Alexandrov.

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