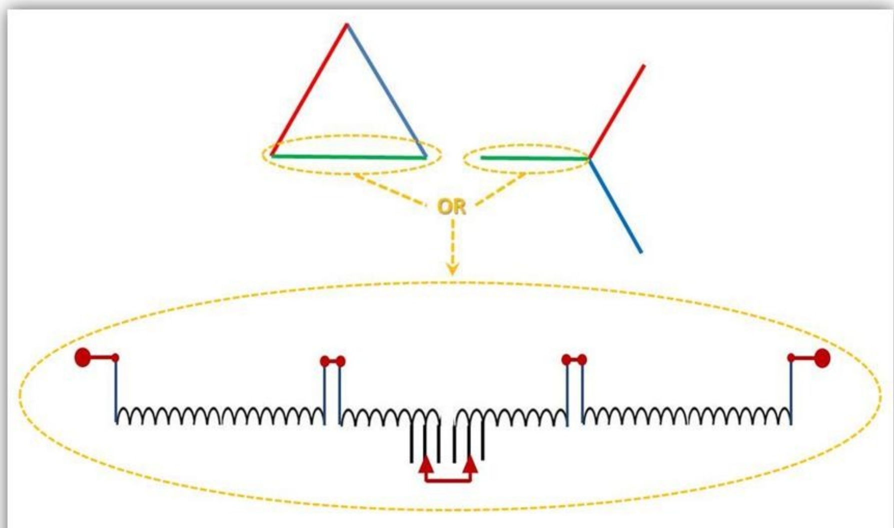
January, 2014

Dual Voltage Transformers

Transformers with dual voltage primaries have been widely employed as a means to reduce the number of transformers required to accommodate facilities with multiple primary voltage sources. Padmount, station, or secondary unit substation configurations may be provided with dual voltage capabilities thereby reducing the number of spare transformers inventoried as back-ups in critical load environments.

There are several means in which to provide the dual voltage option. This paper will serve as an introduction on the subject and therefore focus on the “standard” approach.

To simplify the topic, all examples will be focused on the high voltage configuration on one phase of a 3 phase transformer whether delta or wye connected, as illustrated to the right. Transformer style (pad, station,….), conductor, fluid, accessories, etc. have no affect on the dual voltage configuration.



Series Connected Phase Winding

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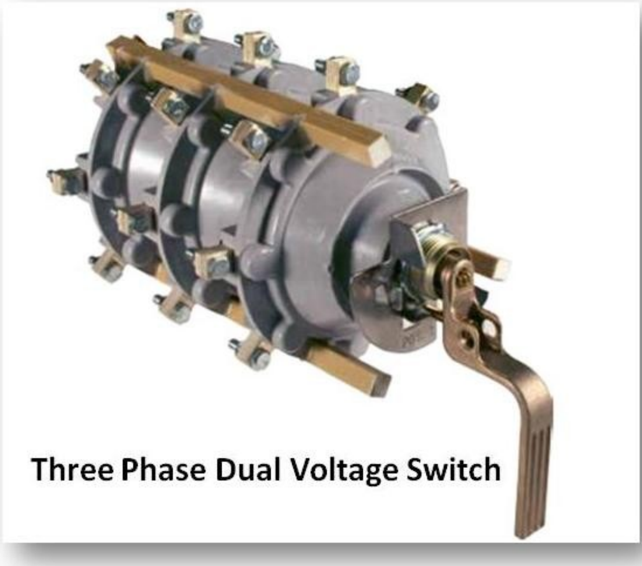
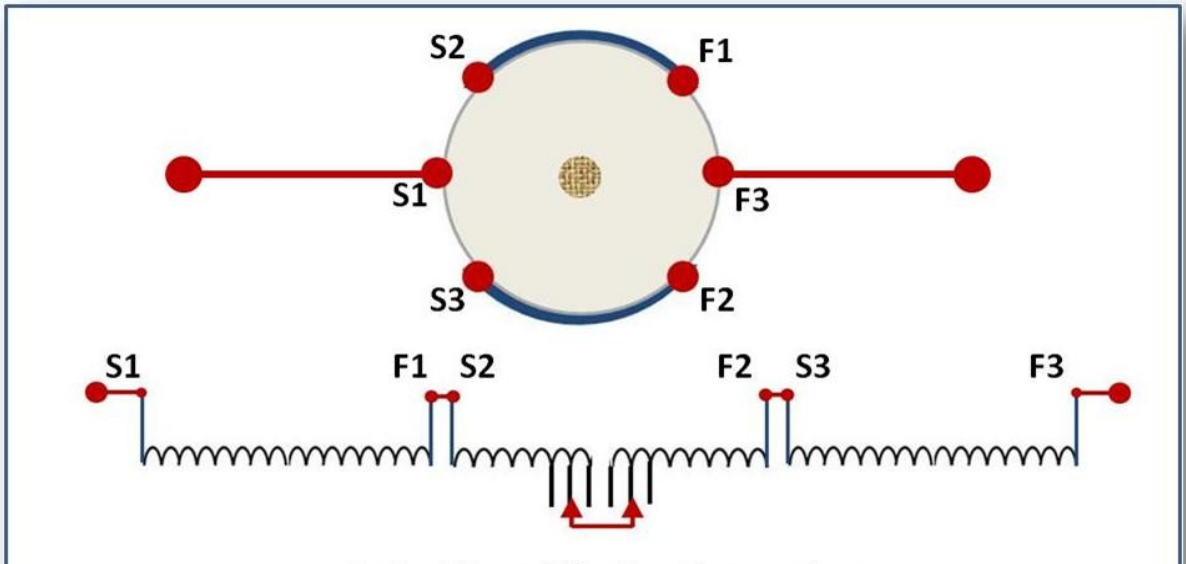
Typical distribution voltages found in dual voltage transformers include:
4160GrdY/2400 x 12470GrdY/7200
4160Grdy/2400 x 13200GrdY/7620
8320GrdY/4800 x 24940GrdY/14400
12470GrdY/7200 x 24940GrdY/14400
13200GrdY/7620 x 24940GrdY/14400


Three Phase Dual Voltage Switch

Three phase dual voltage switches (also known as series/multiple switches) are available to allow for connection changes to the windings by way of a switch handle located on the outside wall of the transformer tank. They are however, no-load devices and therefore may only be operated while the transformer is deenergized.

Dual voltage primaries are constructed so as to enable sections of phase windings to be connected in series or parallel.

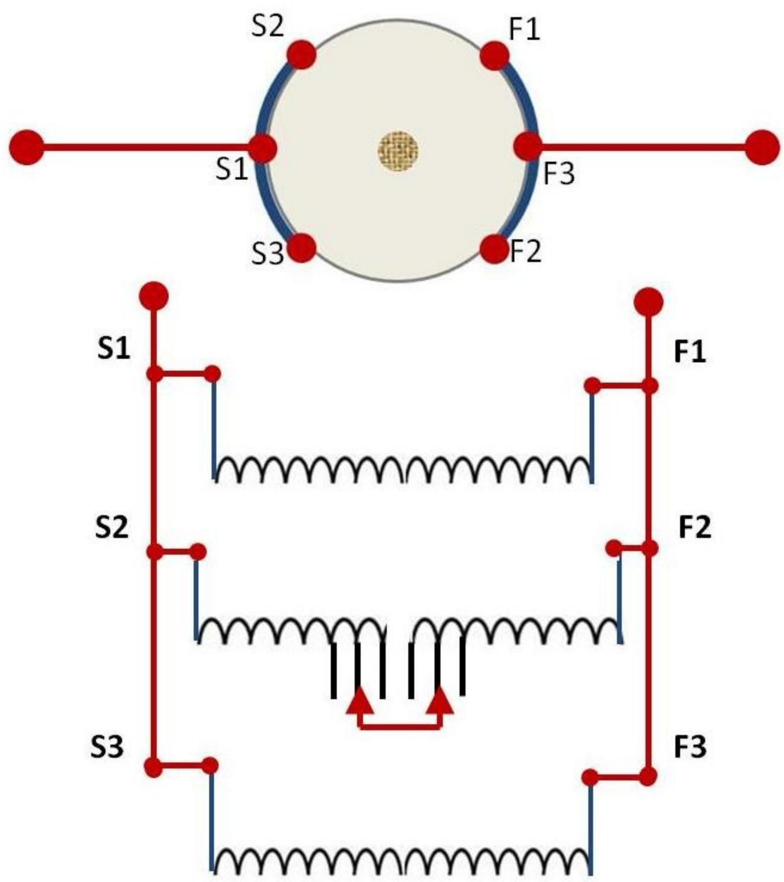


Series Phase Winding Connections

In the above illustration, the phase windings are connected in series, thereby resulting in a cumulative total of primary turns. Since the transformer low voltage turns do not change, the series connection provides for the highest turns (and voltage) ratio. The “S” labels denote windings starts while the “F” labels denote finishes. The upper sketch depicts one deck of a dual voltage switch and shows how the upper and lower contact bars (blue) complete the connections shown in the winding diagram below it.

The center winding in this example reveals a tap section which may be used in making voltage adjustments while in this series connection. Although non-standard taps are available, typical taps are set at 2 taps above nominal in 2.5% increments, 2 taps below nominal in 2.5% increments, and a center tap at nominal voltage.

In the following illustration, the dual voltage switch has been rotated to connect all starts and finishes.

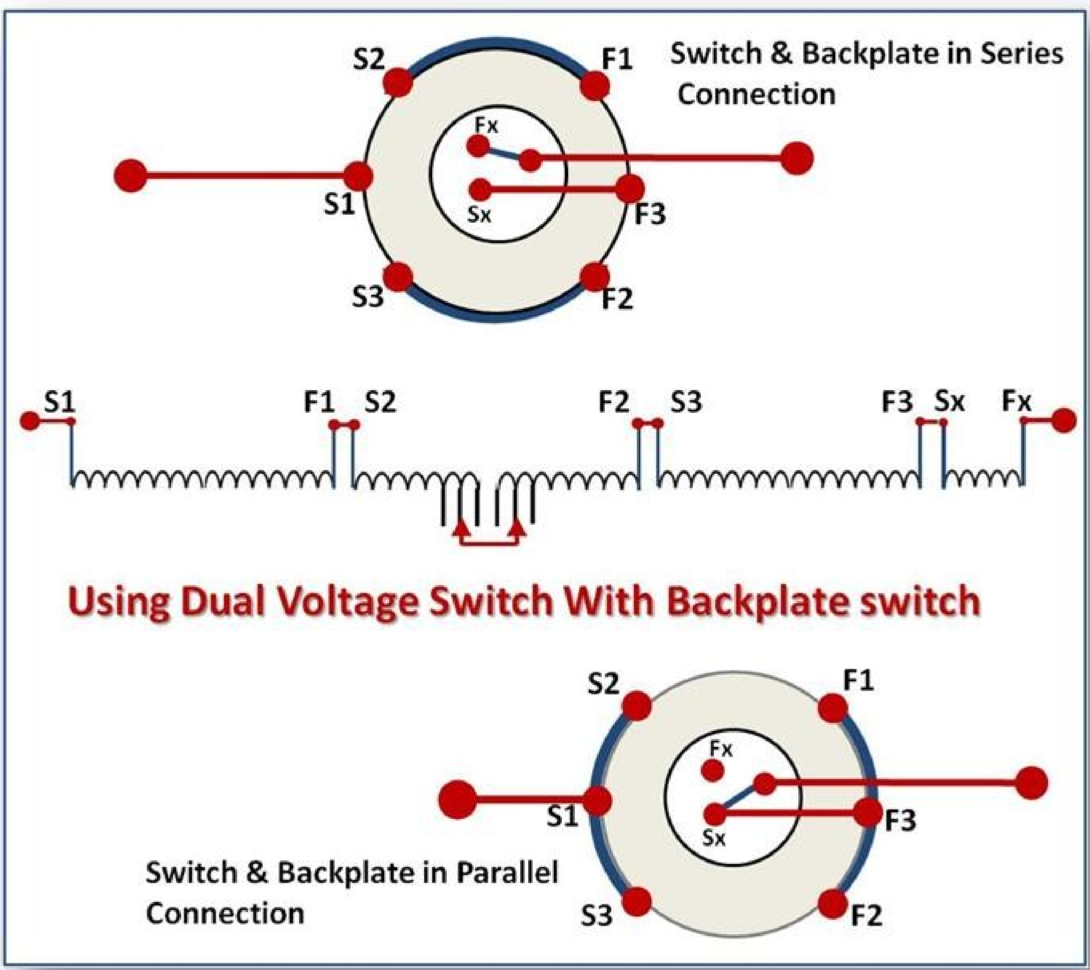


Paralleled Phase Winding Connections

The phase windings are now connected in parallel. The tap changer must be in the nominal position in order to have the turns in the center section equal those in the other sections. In this position the tap changer cannot be used since to do so would create a virtual “short circuit” in the winding.

The paralleled windings decrease the total turns to one third of those in the series position thereby decreasing the turns (and voltage) ratio by two thirds.

The preceding examples work fine when the phase voltages are in even multiples. For example if the lower voltage is 2400 and the higher is 7200, 3 identical windings can be used. On the other hand, if the lower voltage is 2400 and the higher is 7620, special accommodations must be made.



The above illustration depicts a phase winding comprised of three standard and equal sections plus an additional winding section labeled Sx Fx. The dual voltage switch includes the addition of a “backswitch”.

For this example we’ll assume a wye connected dual voltage primary rated at 4160Grdy/2400 x 13200GrdY/7620. With this being the case, in the series (high voltage) position, each phase would be comprised of 3 equal 2400 volt windings PLUS a “special” section comprised of the necessary additional turns to add 420 volts to the winding (2400 + 2400 + 2400 +420 = 7620).

In the preceding illustration, the upper switch connection drawing reveals the series interconnections between the 3 each 2400 volt windings as well as the inclusion of the Sx Fx section of the winding by way of a backswitch incorporated on the dual voltage switch. Under this condition, the transformer primary is connected at 13200Y/7620.

The lower switch connection drawing depicts the switch connections once placed in the paralleled connection position. Note that while in this position, the Sx Fx section of the winding has been bypassed by the backwsitch. The remaining sections at 2400 volt each have been paralleled thereby making the necessary connections for 4160Y/2400 volt operation.

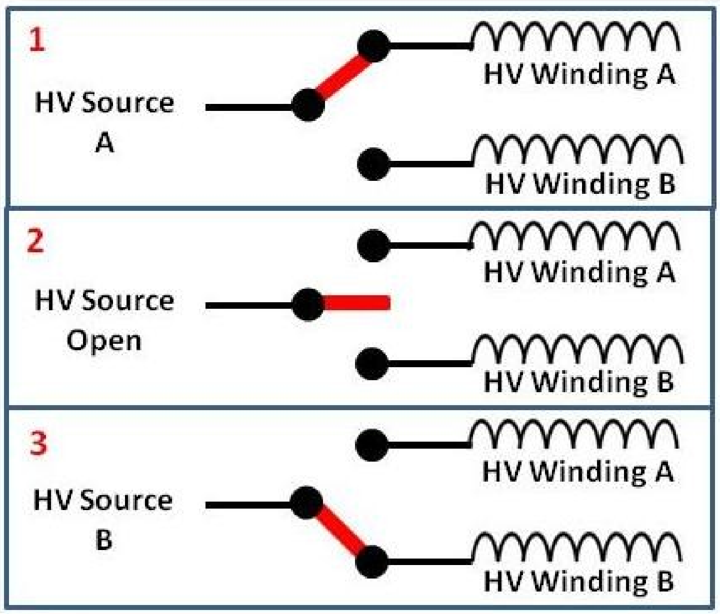
With or without the backswitch, high voltage taps are only available in the higher voltage connection. There are ways to enable tap selections for the lower voltage connection, but they are complex, may require separate tap changers per phase, and can be quite costly.

If it is deemed that taps ***are*** a requirement for both the lower higher voltage, another solution is available and is widely used. In lieu of a dual voltage connection, an additional, independent high voltage winding may be used. In doing so, the windings for each voltage are independent and therefore can include taps specific to the selected high voltage. The transformer cost may however, increase since replacing a shared winding with an independent winding results in an increase in the total size of the transformer due to a larger core/coil assembly.

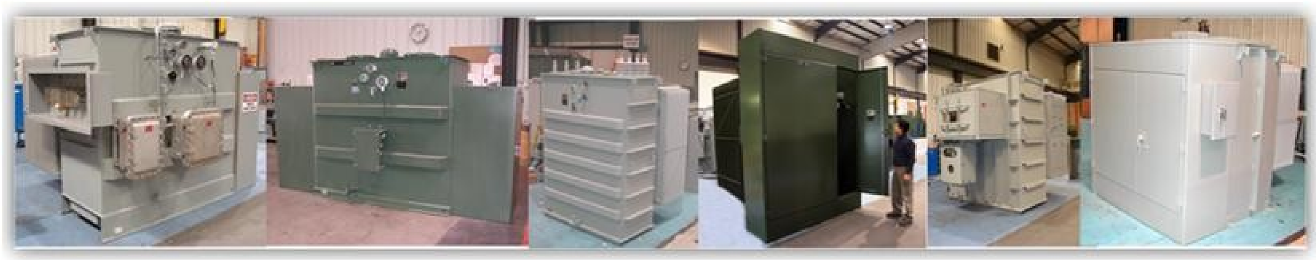
If an additional high voltage winding is used, the dual voltage switch is no longer required and is replaced with a sectionalizer switch. This type of switch is routinely used in loop feed applications with "V" of "T" blade configurations as addressed in a previous topic paper. This switch can also be configured however, to "select and connect" one of 2 windings within the transformer tank connecting same to the high voltage bushings.

Three phase Loadbreak Sectionalizer Switch

The drawing to the right shows the 3 positions available when using the appropriate sectionalizer switch with dual high voltage windings. Although used with 3 phase applications, it is shown as single phase to simplify.



In the first position, each phase of winding A is internally connected to the appropriate high voltage bushing. In the next position the transformer is disconnected from the source. Unlike the dual voltage switch, this switch is a loadbreak device and therefore can be operated while energized. The third position connects each phase of winging B to the high voltage bushings.



Since there are 2 independent high voltage windings, tap changers specific to each winding are used. The tap position therefore, is not a concern when changing between high voltages.

Regardless of whether a dual voltage or sectionalizer switch is used, the operating voltage and current ratings must be properly selected. Each switch must be rated to handle the higher voltage as well as the higher current required when in the lower high voltage connection.

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