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Mid-Line Segmentation To Increase Voltage Profile

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***Abstract*— It is of paramount importance to a transmission line to have a steady state supply of power. This study has been documented on the basis that the steady-state transmittable power can be improved as well as the voltage contour along the line. The main objective is to apply reactive shunt compensation in a transmission line is to increase the transmittable power. These methods used to increase the steady state power transmission and stability of system. Var compensation in practical application is often used to regulate the bus voltage against load variation due to generation or line outages.**

***Keywords*— Capacitor; inducto; line; segments**

I. Introduction

It is a well-observed phenomenon the steady-state power of a transmission line can be improved considerably.

The basic approach is that to increase steady-state transmittable power and the voltage along the line. The reactive compensation is to change the transmission line parameter to make it more feasible and correct with the main load demand. Thus, shunt connected, static or automatically switched reactors can be applied to reduce line overvoltage under light load conditions. And shunt connected, static or automatically switched capacitors can be applied to maintain voltage level under high load conditions. The basic importance to increase the transmittable power by model shunt-connected Var compensation will be reviewed in order to provide a base or power electronics-based compensation and control method to meet exact compensation objectives. The basic purpose of reactive shunt compensation is to raise the transmittable power. Var compensation is thus used for voltage regulation at the midpoint of transmission line and voltage instability.

II. MIDPOINT VOLTAGE REGULATION FOR LINE SEGMENTATION

Consider the simple two bus machine transmission model in which an ultimate Var compensator is connected at the center of transmission line, as shown in Figure1 (a). For simplicity, the line is represented by the series line inductance. The compensator is represented by a sinusoidal ac voltage source, in-phase with the midpoint voltage, Vm, and with an amplitude equal to that of the sending- and receiving-end voltages must be such that Vm=Vs =Vr= V.

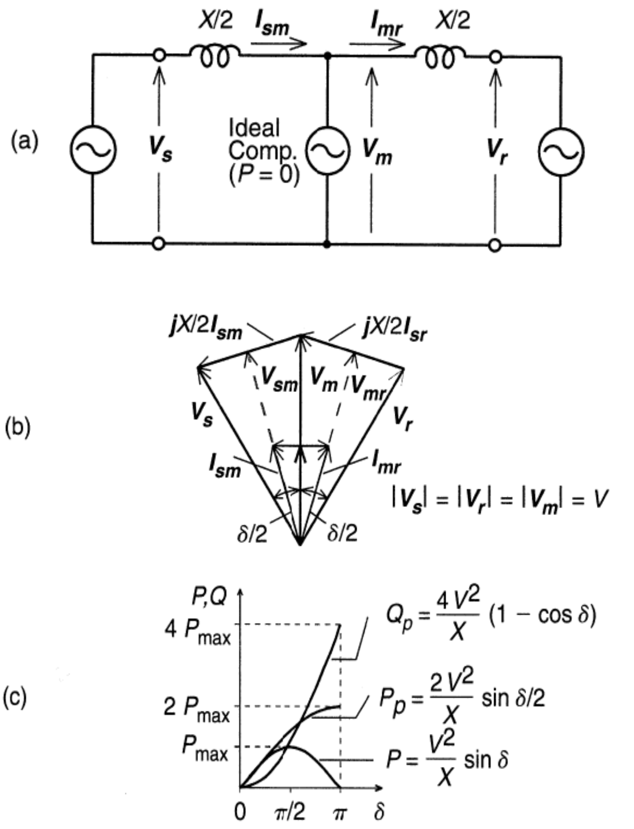

Figure1:(a)Two machine power system with midpoint reactive compensator(b) phasor diagram(c)Plot power transmission P,Q vs. angle δ.

The midpoint compensator result the transmission line into two impartial parts: the first segment, with an impedance of X/2, transmits power from the sending end to the midpoint. The second segment also with an impedance of X/2, transmits power from the midpoint to the receiving end. The connection between voltages, Vm, Vs, Vr, Vsm, Vmr and line segment currents Ism and Irm is shown in the phasor diagram in Figure 1(b). In this process the midpoint Var compensator can exchanges only reactive power with the transmission line. For the assumed lossless system, the real power is the same at each terminal that is sending end; midpoint and receiving end of the line. It can be derived easily from the phasor diagram of Fig. 1(b). With

$$Vsm = Vmr = V\cos\frac{\delta}{4};$$

$$Ism = Imr = I\ \frac{4V}{X}\sin\frac{\delta}{4}$$

The Transmitted power is

$$P = VsmIsm = VmrImr = VmIsm\ \cos\frac{\delta}{4} = VI\cos\frac{\delta}{4}$$

$$P = 2\frac{V^2}{X}\sin\frac{\delta}{2}$$

Similarly

$$Q = VI\ \sin\frac{\delta}{4} = \frac{4V^2}{X}(1 - \cos\frac{\delta}{2})$$

The association between real power P, reactive power Q, and angleδ for the case of perfect shunt compensation is shown plotted in Figure1(c). It can be observed that the midpoint shunt compensation can expressively increase the transmittable power at the cost of a rapidly increasing reactive power demand on the midpoint compensator (and also on the end-generators).It is also evident that for the single-line system of Figure1 the midpoint of the transmission line is the best location for the compensator. This is because the voltage sag along the uncompensated transmission line is the largest at the midpoint. Also, the compensation at the midpoint breaks the transmission line into two equal segments for each of which the maximum transmittable power is the same. For unequal segments, the transmittable power of the longer segment would clearly determine the overall transmission limit.

III. MULTIPLE COMPENSATORS

If the power has to be transferred through long distance transmission lines, use of parallel lines reduce transfer reactance as well as improve voltage regulations. Similarly series capacitors are sometimes employed in lines to get the same features.
The idea of transmission line segmentation can be extended to the use of Multiple Compensators located at equal segments of the transmission line, as illustrated for four line segments in Figure 2. Theoretically, the transmittable power would double with each doubling of the segments for the same overall line length. Furthermore, with the increase of the number of segments, the voltage variation along the line would rapidly decrease, approaching the ideal case of constant voltage profile. Ultimately with a large number of line segments, an ideal distributed compensation system could theoretically be recognized, which would have the characteristics of usual surge impedance loading, but would have no power transmission limits and would maintain a flat voltage profile at loads.
It is valued that such a distributed compensation pivots on the instantaneous response and limitless Var generation and absorption ability of the shunt compensators. This would have stay in synchronism with the usual phase of the segment voltages and maintain the predefined amplitude of the voltage impartially of load variation.
Such a system, however, would tend to be too complex and perhaps too expensive, to be practical, mainly stability and reliability requirements under suitable possible conditions are also considered. However, the practically line segmentation, using thyristor-controlled static Var compensators has been demonstrated by the major, 600 mile long,735 kV transmission line of the Hydro-Quebec.

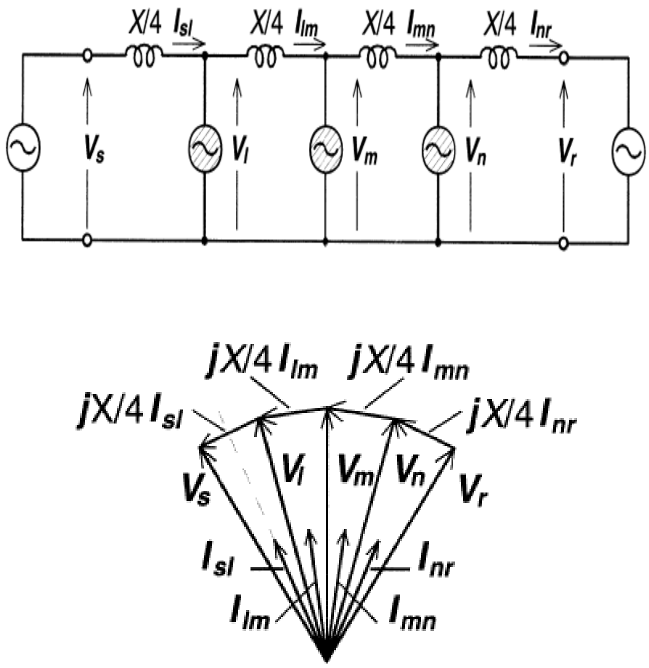

Figure2: Two machine system with reactive Var compensator maintaining constant transmission voltage profile by line segmentation and phasor diagram

Power station built to transmit up to 12000MW power to the Montreal city and to adjacent U.S. utilities. More importantly, the transmission advantages of voltage support by controlled shunt compensation at tactical locations of the transmission system have been demonstrated by several installations in the world.

IV. MODEL DEVELOPMENT

The Simulation model is performed in Matlab as shown in figure 3.

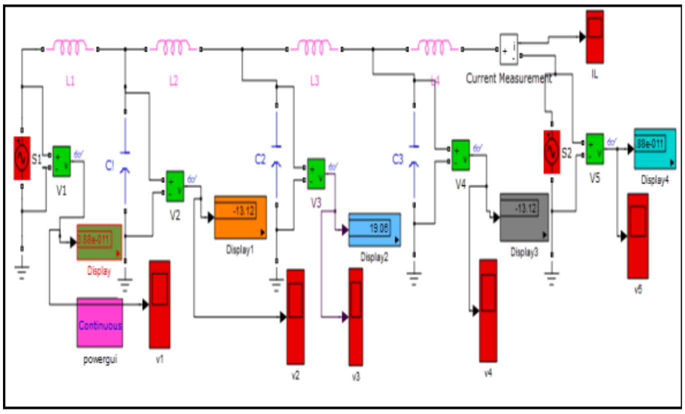

Figure 3. Simulation Model

V. RESULTS AND DISCUSSION

The model is simulated for time period of 0.2 sec and the output voltages of simulation are as below:

MEASUREMENTS:

1. V1 = 1414.00 V
2. V2 = 1653.70 V
3. V3 = 1736.21 V
4. V4 = 1653.70 V
5. V5 = 1414.00 V
6. Current = 2.85 A -90.00°

SOURCES:

1. S2 = 1414.00 V
2. S1 = 1414.00 V

The waveforms are as follows:

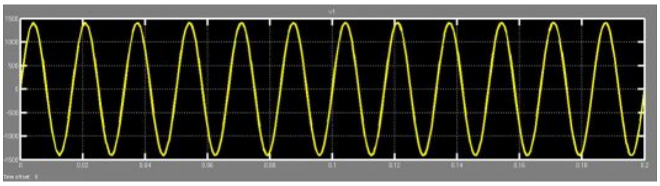

Figure 4: Source S1voltage waveform

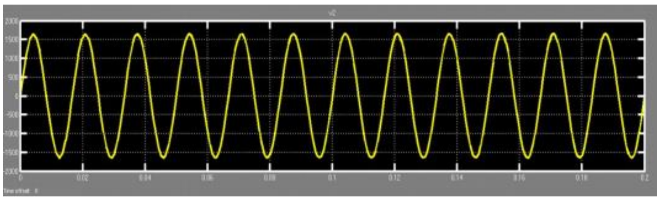

Figure 5: Voltage waveform across C1

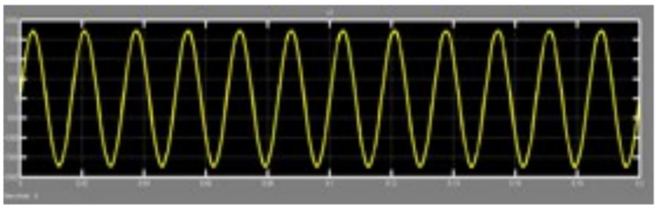

Figure 6: Voltage waveform across C2

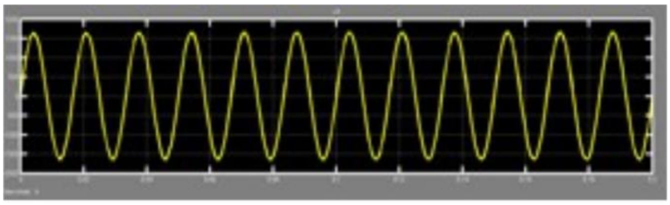

Figure 7: Voltage waveform across C3

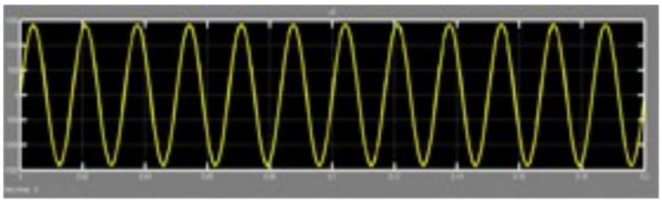

Figure 8:Source S2 voltage waveform

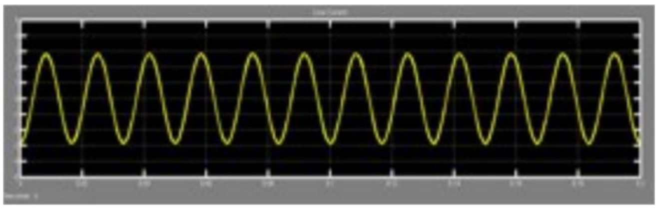

Figure 9: Line current waveform

VI. CONCLUSION

From the above simulation results, mid-point line segmentation carried out is useful for power transfer and can be implemented in line segmentation. Also, power transfer can be increased by the voltage profile by shunt compensation. This can be applicable to minimise overvoltage below light load conditions and to maintain the voltage level above heavy load conditions.

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