SIMULATION OF DYNAMIC VOLTAGE RESTORER FOR POWER FLOW USING PSPICE

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Abstract: *To achieve operational reliability and financial profitability more efficient utilization and control of the existing transmission system infrastructure is required. Mechanical switch based traditional approaches cannot realize full utilization of transmission system due to the needed large stability margin. Flexible Alternating Current Transmission System (FACTS) is a power electronics based real time computer controlled technology provides needed corrections of transmission functionality in order to efficiently utilize existing transmission systems and therefore minimizing the gap between the stability and the thermal levels. Dynamic Voltage Restorer (DVR) is a Voltage Source Converter (VSC) based FACTS controller for series compensation with the unique capability of power flow management among multi-lines of a Substation. Basic principles of the DVR simulated using PSPICE and discussed. Simulation results demonstrate the capability of DVR to realize power balance in a transmission system with two identical lines and two non-identical lines.*

Key words: FACTS, DVR, VSC, Power flow control, Voltage regulation.

1. Introduction

The ongoing expansion and growth of the electric utility industry continuously introduce changes to a once predictable business. Electricity is increasingly being considered and handled as a commodity. Thus transmission systems are being pushed closer to their stability and thermal limits with the focus on the quality of power delivered The Dynamic Voltage Restorer or Voltage Sag Compensator is a power electronics-based equipment designed to compensate voltage disturbances, as voltage sags and swells, reducing transient and harmonic voltages from the utility grid and preventing sensitive loads from disruption [1,2]. Since the compensator can be subjected to a variety of disturbances, as voltage and current surges, specific mechanisms and systems should be available, in order to guarantee its correct operation and avoid undesired failures, especially due to voltage surges and short-circuits at the load side.

2. Performance of DVR System

In normal situation without short circuit in power system, a capacitor between rectifier and inverter (Figure.1) will be charging. When voltage sag happened, this capacitor will discharge to maintain load voltage supply. Nominal voltage will be compared with voltage sag in order to get a difference voltage that will be injected by DVR system to maintain load voltage supply. PWM technique is using to control this variable voltage [3, 4]. In order to maintain load voltage supply, reactive power must be injected by DVR system. Practically, the capability of injection voltage by DVR system is 50% of nominal voltage. It is sufficient for mitigation voltage sag because from statistic shown that many voltage sag cases in power system involving less than 0.5 p.u. voltage drop [5].

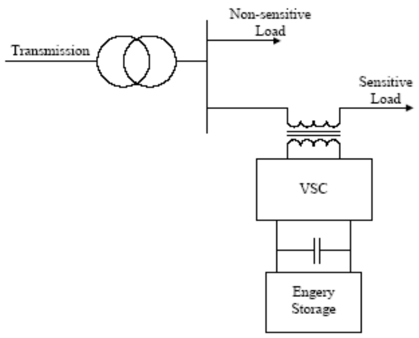

Fig (a)

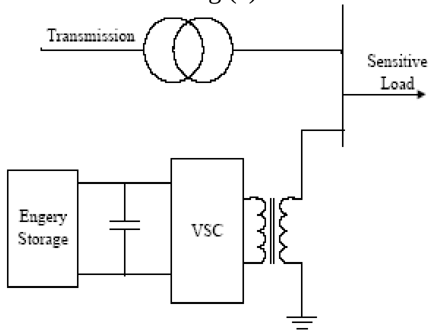

Fig (b)

Fig. 1 (a) and (b). Interconnection schematic of series and shunt compensated DVR system.

3. Simulation of DVR with Out Transmission Line

In this system we considered a 11kv transmission line without DVR.By increase the load of a system, the transmission line regulation and efficiency decreases, the system transmission loss is increases. The simulation circuit of DVR without transmission system is as shown in Fig.2.

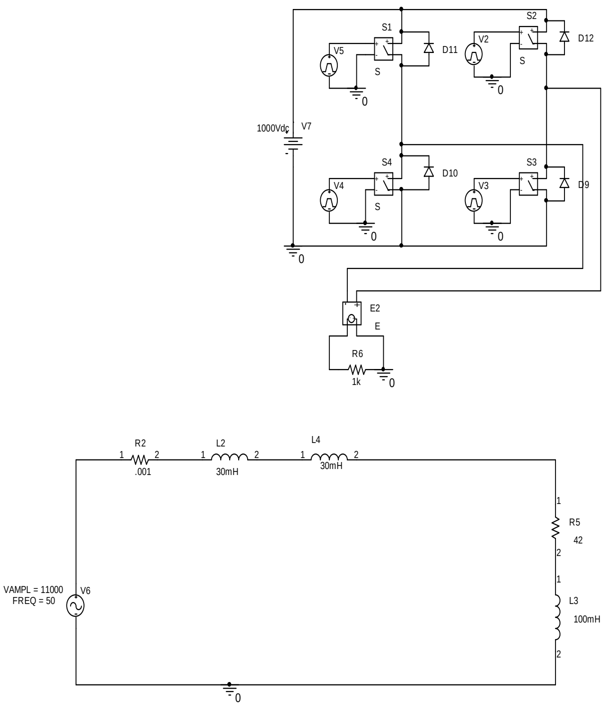

Fig. 2. Circuit diagram for DVR without transmission line

Here there is no any compensation devices are injected, so the system having a poor power factor under over loaded conditions. The various simulation results of input current, voltage and power factor as shown on the Fig.2 (a).

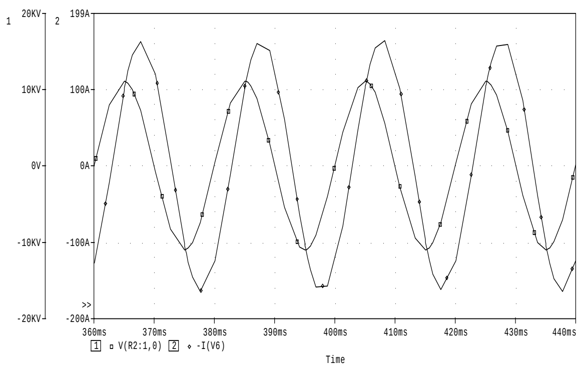

Fig .2 (a). waveform for Input voltage and Input current without DVR, PF=0.5866

4. Simulation of DVR with Transmission Line

In this system we having a same transmission line model are analyzed. The input 6kv dc voltage are connected by using converters and then to maintain the stability of input voltage using the capacitor. The simulation of DVR with transmission line is as shown in the Fig.3.

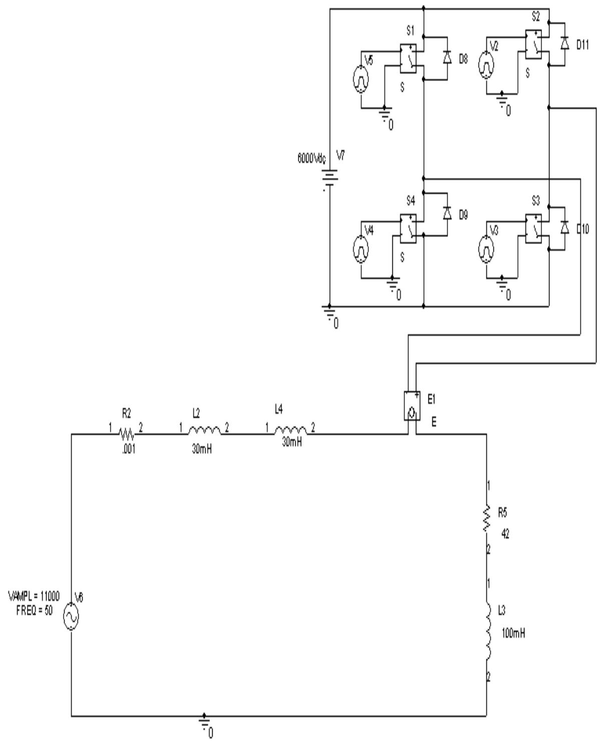

Fig. 3. Circuit diagram of DVR with transmission line

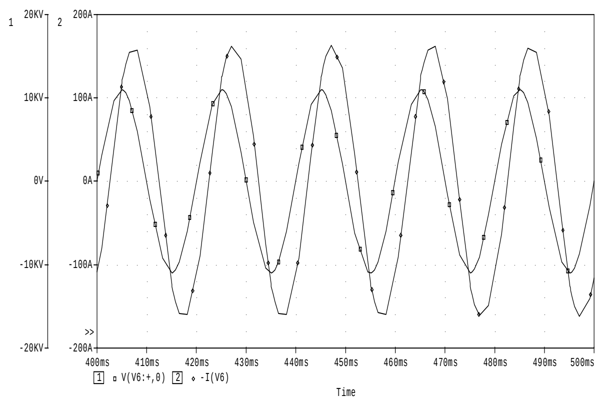

Fig. 3(a). Waveform for Vdc is 1kv and P.F=0.6845

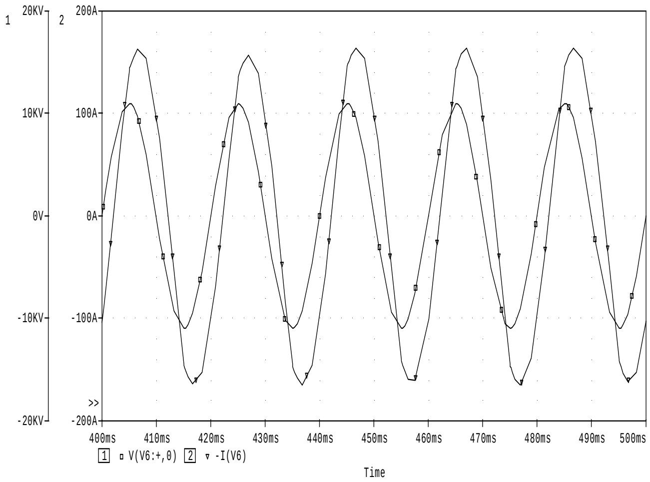

Fig. 3 (b). Waveform for Vdc is 2kv and P.F=0.7804

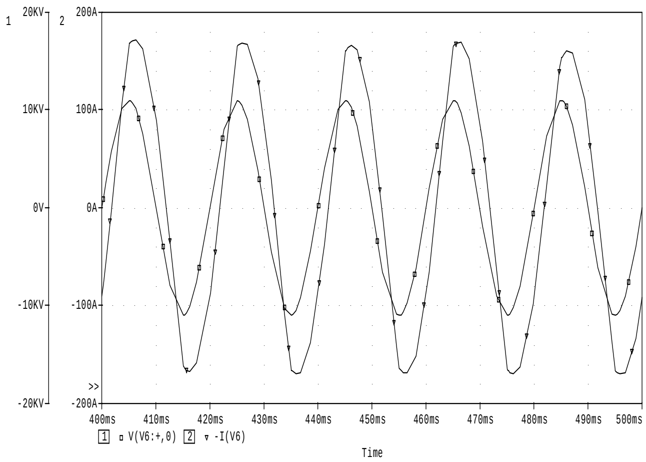

Fig. 3 (c). Waveform for Vdc is 3kv and P.F=0.8443

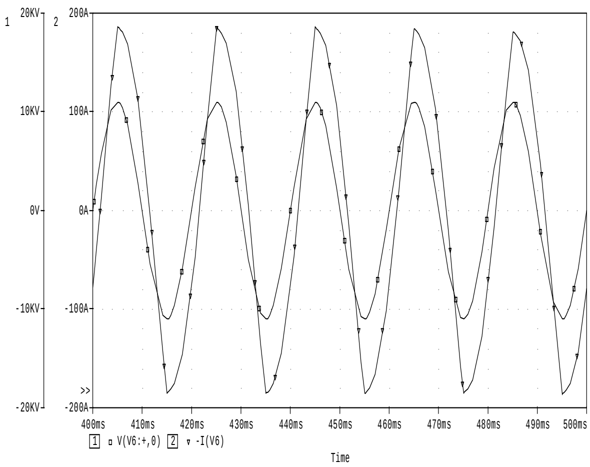

Fig. 3 (d). Waveform for Vdc is 4kv and P.F=0.8910

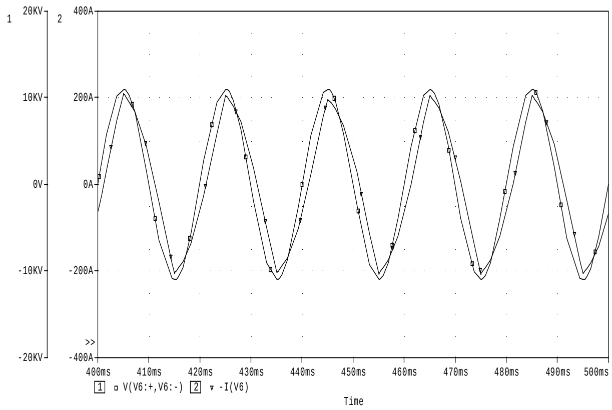

Fig. 3 (e). Waveform for Vdc is 5kv and P.F=0.9297

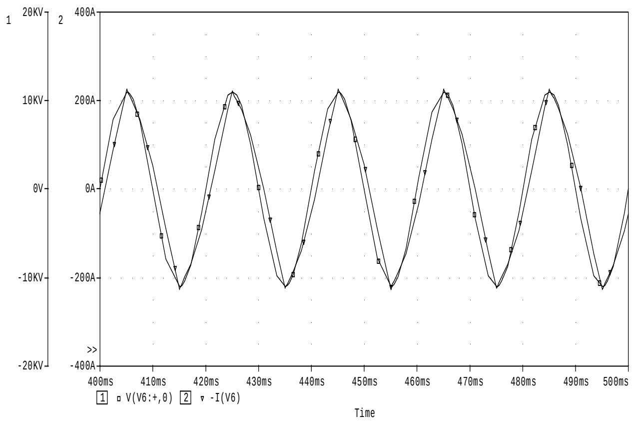

Fig. 3 (f). Waveform for Vdc is 6kv and P.F=0.9550

The inverter operation is performed when the operating angle is greater than the 90° conditions; this ac voltage is injected in a transmission system. By increasing the injecting voltage of a line we are easily to control the over loading of a line and the regulation, efficiency is increased [6]. The power factor of a system to maintain the superior level. The different simulation results of injecting voltage and the power factor is as shown in the Fig.3 (a) to 3 (f) respectively.

5. Simulation of Two Non Identical Lines

In this system two non identical lines are analyzed DVR as shown in Fig.4.The voltages are 11kv and 10kv respectively. In this arrangement which transmission line having an more power flow that power fed through the converters and injected to the another line (which line is severely affected in more voltage sag).In this system the capacitor to maintain the input voltage source of inverters. By increasing the injecting voltage the real power flow increases and reactive power flow decreases as shown in the Fig.4 (a) to 4(d) respectively.

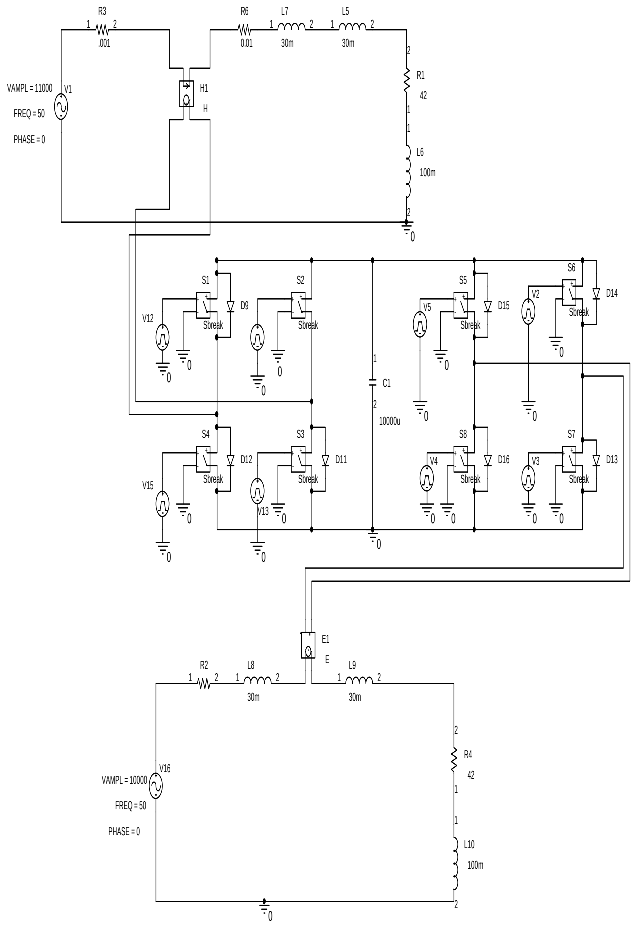

Fig. 4. circuit diagram for DVR in transmission system with two non-identical lines

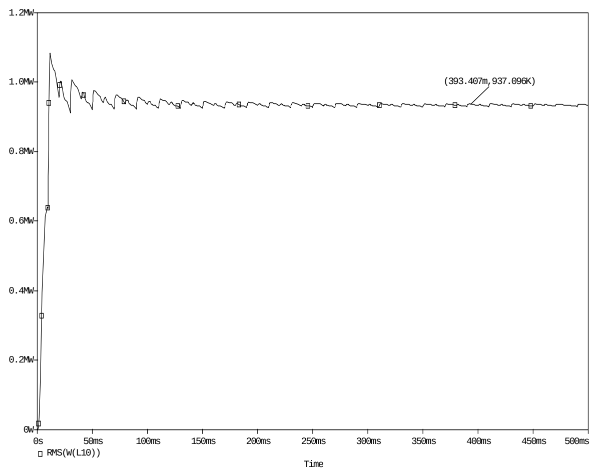

Fig. 4 (a). Rms Reactive power in the Line2

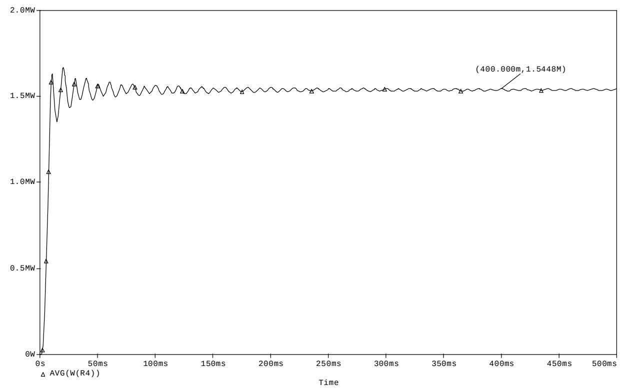

Fig. 4 (b). Real power in the Line2

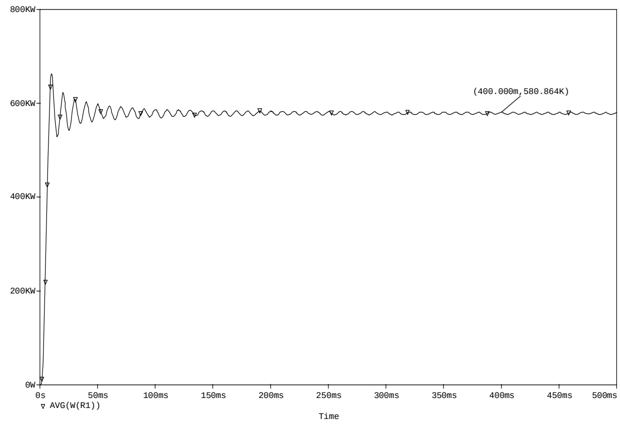

Fig .4 (c). RmsReactive power in theLine1

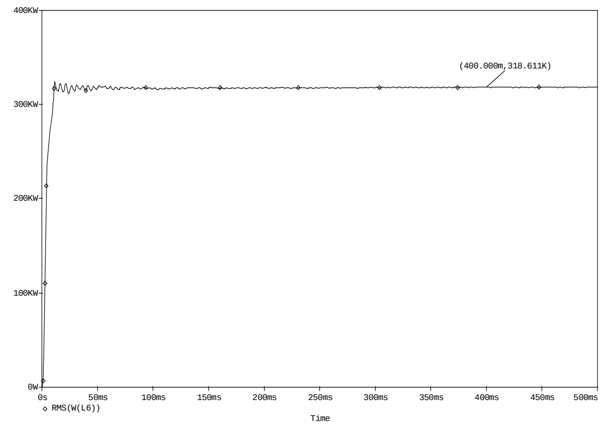

Fig . 4 (d). Real power in theLine1

6. Simulation of Two Identical Lines

In this system two non identical lines are analyzed DVR as shown in Fig.4.The voltages are 11kv and 11kv respectively. By increasing the injecting angle of inverters the injecting voltage is increasing on a line, this injecting voltage is injected in which line is severely loaded and the highest values of voltage sag [7, 8]. Hence the line is compensated and the better power balance is performed. By using in this scheme the power factor of a transmission line is improved. The voltage sag of a transmission lines are minimized and regulation is improved using in this system. The various simulation results of real and reactive power flow is as shown in the Fig.5 (a) and 5(b) respectively.

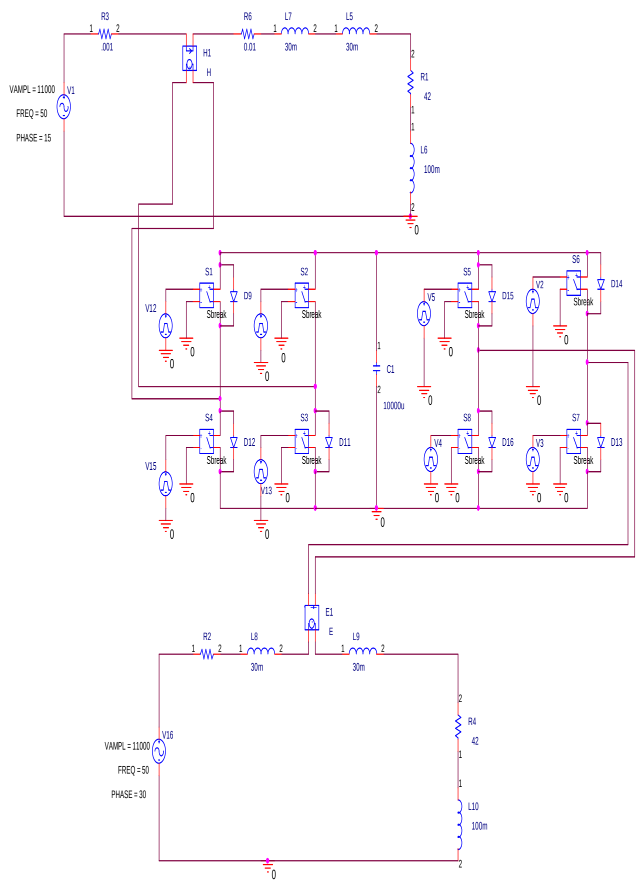

Fig. 5. Circuit diagram for DVR in transmission system with two non-identical lines

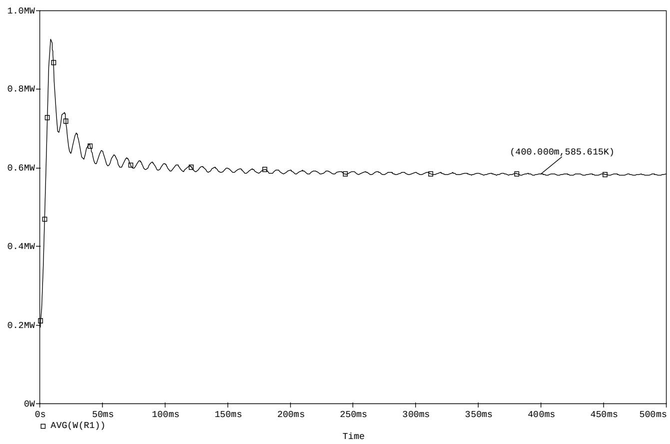

Fig. 5 (a). Real power in line2

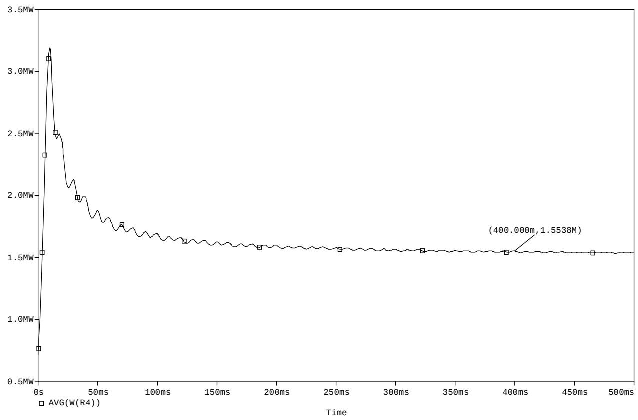

Fig. 5 (b). Real power in line1

7. Conclusion

In this paper the DVR with and without transmission lines are analyzed. By using DVR system the real power, regulation, efficiency, power factor of a transmission line is improved and the reactive power flow is controlled. The DVR system is designed for series connection in a distribution line. It maintains the voltage applied to the load during sags and swells by injecting a voltage of compensating amplitude and phase angle into the line. For energy suppliers, this DVR to satisfy the stringent power quality demands of industrial and commercial customers. It also provides a means for energy users to isolate themselves from voltage sags and unexpected load changes originating on the transmission or distribution system.

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