Dynamic Voltage Restorer Application for Power Quality Improvement in Electrical Distribution System: An Overview

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Abstract: Dynamic Voltage Restorer (DVR) is a custom power device that is used to improve voltage disturbances in electrical distribution system. The components of the DVR consist of voltage source inverter (VSI), injection transformers, passive filters and energy storage. The main function of the DVR is to inject three phase voltage in series and in synchronism with the grid voltages in order to compensate voltage disturbances. The Development of DVR has been proposed by many researchers. This paper presents a review of the researches on the DVR application for power quality improvement in electrical distribution network. The types of DVR control strategies and its configuration has been discussed and may assist the researchers in this area to develop and proposed their new idea in order to build the prototype and controller.

Key words: Dynamic voltage restorer, controller, injection transformer, review, voltage source inverter.

INTRODUCTION

Recently applications of power electronic controller based on Custom Power Devices (CPD) are widely used in electrical distribution system for power quality improvement. CPD is a powerful tool based on semiconductor switches concept to protect sensitive loads if there is a disturbance from power line (Middlekauff, et al., 1998). Among the several novel CPD, the Dynamic Voltage Restorer (DVR) are now becoming more established in industry to mitigate the impact of voltage disturbances on sensitive loads. (A. Ghosh, et al., 2002; S.S. Choi, et al., 2000). Power quality in the distribution system can be improved by using a custom power device DVR for voltage disturbances such as voltage sags, swells, harmonics, unbalanced voltage and etc (Zhan, et al., 2003). The function of the DVR is a protection device to protect the precision manufacturing process and sophisticated sensitive electronic equipments from the voltage fluctuation and power outages. The DVR has been developed by Westinghouse for advance distribution. The DVR is able to inject a set of three single-phase voltages of an appropriate magnitude and duration in series with the supply voltage in synchronism through injection transformer to restore the power quality (J.G. Nielsen, et al., 2005; D.M. Vilathgamuwa, et al., 2004). The DVR is a series conditioner based on a pulse width modulated voltage source inverter, which is generating or absorbing real or reactive power independently. Voltage sags caused by unsymmetrical line-to-line, line to ground, double-line-to-ground and symmetrical three phase faults is affected to sensitive loads, the DVR injects the independent voltages to restore and maintained sensitive to its nominal value. The injection power of the DVR with zero or minimum power for compensation purposes can be achieved by choosing an appropriate amplitude and phase angle (Li, et al., 2007).

2.1 Dynamic Voltage Restorer (DVR): The conventional circuit configuration of the DVR is shown in Figure 1. Dynamic voltage restorer is a series connected device is used for mitigating voltage disturbances in the distribution system (Lee, et al., 2004). The DVRs can be used and are already in operation (W.E. Brumsickle, et al., 2001). DVR maintains the load voltage at a nominal magnitude and phase by compensating the voltage sag/swell, voltage unbalance and voltage harmonics presented at the point of common coupling (Mahesh, et al., 2008; L.P. Lowder, et al., 2009; Ramachandaramurthy, et al., 2004). These systems are able to compensate voltage sags by increasing the appropriate voltages in series with the supply voltage, and therefore avoid a loss of power. In 1994, L.Gyugyi (Patent No. 5329222) proposed an apparatus and a method for dynamic voltage restoration of utility distribution network. This method uses real power in order to inject the faulted supply voltages and is commonly known as the Dynamic Voltage Restorer (Gyugyi, et al., 1994). The DVR should capable to react as fast as possible to...
inject the missing voltage to the system due to sensitive loads are very sensitive to voltage variations (Chan, et al., 2006). The DVR is a series conditioner based on a pulse width modulated voltage source inverter, which is generating or absorbing real or reactive power independently. Voltage sags caused by unsymmetrical line-to-line, line to ground, double-line-to-ground and symmetrical three phase faults is affected to sensitive loads, the DVR injects the independent voltages to restore and maintained sensitive to its nominal value. The compensation of harmonics and mitigates voltage transients has been discussed in (Li, et al., 2001).

2.2 The basic components of a DVR:

DVR can be applied for medium voltage (Li, et al., 2007; Toodeji, et al., 2009; Meyer, et al., 2008) and in low voltage application (Muni et al., 2004). The DVR components has been discussed in (Zhan, et al., 2002; Chun, et al., 2003; Zhan, et al., 2003).

The DVR system consists of two (2) important components namely a power circuit and a control unit. A comprehensive literature survey of DVR including power circuit, control unit and its application in electrical distribution system is discussed. Power circuit of DVR basically consists of a voltage source inverter, a series-connected injection transformer, an inverter output passive filter, and an energy storage device that is connected to the dc link (Boonchiam, et al., 2006; Ezoji, et al., 2009; Banaei, et al., 2006; Ghosh, et al., 2002; Nguyen, et al., 2004) as follows.

- Series Voltage Injection Transformers
- Energy Storage
- Passive Filters
- Voltage Source Inverter (VSI)
- By Pass Switch

Power Circuit of a DVR is shown in Figure 2. In DVR the control circuit is used to derive the parameters (magnitude, frequency, phase shift, etc) of the control signal that has to be injected by the DVR. Based on the control signal, the injected voltage is generated by the switches in the power circuit (Zhan, et al., 2002; Kim, et al., 2005).

2.2.1 Series Voltage Injection Transformers:

In a three-phase system, either three single-phase transformer units or one three phase transformer unit can be used for voltage injection purpose (Zhan, et al., 2000). The injection transformer comprises of two side voltages namely the high voltage side and low voltage side. Normally the high voltage side of the injection transformer is connected in series to the distribution system while power circuit of the DVR can be connected at the low voltage side. The basic function of the injection transformer is to increase the voltage supplied by the filtered VSI output to the desired level while isolating the DVR circuit from the distribution network. The transformer winding ratio is pre-determined according to the voltage required in the secondary side of the transformer (generally this is kept equal to the supply voltage to allow the DVR to compensate for full voltage sag (Zhan, et al., 2001). A higher transformer winding ratio will increase the primary side current, which will adversely affect the performance of the power electronic devices connected in the VSI. Three single phase or three-phase voltage injection transformers can be used for a three-phase DVR. In this case the high voltage of the injection transformer is connected to the distribution line and for single phase DVR one single-phase injection transformer can be connected (Zhan, et al., 2001). The single phase transformers can be used to inject the compensating voltages separately when three phase inverter is used. To evaluate the performance of the
DVR the rating of the injection transformer is an important factor that need to be considered due to the compensation ability of the DVR is totally depend on its rating. The DVR performance is totally depend on the rating of the injection transformer, since it limits the maximum compensation ability of the DVR (Wang, et al., 2006; Banaei, et al., 2006). In (Loh, et al., 2004; Graovac, et al., 2001) discussed multilevel inverter topology is used in DVR allowing the direct connection of the DVR to the distribution system without using injection transformer.

![Power Circuit of a DVR](image)

**Fig. 2:** Power Circuit of a DVR. (Chan, et al., 1998)

The details explanations of the DVR power circuit components as mentioned earlier can be described as follows:

![Diagram](image)

**Fig. 3(a):** The three single phase transformer connected in delta/open.
The three single phase transformers connection used in the three-phase DVR can be configured either in delta/open or star/open connection as shown in Figures 3(a) and (b). In case of unbalance fault in the high voltage side, the zero sequence current flowing almost zero, if the distribution transformer connection in $\Delta-Y$ with the grounded neutral. As such connection, the DVR is only mitigate the positive and negative sequence components (Fitzer, et al., 2004).

2.2.2 Energy Storage:

The DVR needs real power for compensation purposes during voltage disturbances in the distribution system. In this case the real power of the DVR must be supplied by energy storage when the voltage disturbances exit. The energy storage such as a battery is responsible to supply an energy source in DC form. Energy storage consists of two types form. One using stored energy to supply the delivered power and the other having no significant internal energy storage but instead energy is taken from the faulted grid supply during the sags (John Godsk Nielsen, et al., 2004). A shunt–converter or the rectifier is the main sources of the direct energy storage which is supplied to DVR. Flywheels, batteries, superconducting magnetic energy storage (SMES) and super capacitors can be used as energy storage devices. It is supplies the real power requirements of the system when DVR is used for compensation (Banaei, et al., 2006). The application of the energy storage in DVR is depending on the designed rating required and total cost is also must be considered (H. Awad, et al., 2003). Flywheels, batteries, superconducting magnetic energy storage (SMES) and super capacitors can be used as energy storage devices. It is supplies the real power requirements of the system when DVR is used for compensation lead acid batteries are popular among the others owing to its high response during charging and discharging. But the discharge rate is dependent on the chemical reaction rate of the battery so that the available energy inside the battery is determined by its discharge rate. Storage systems with auxiliary supply is used to increase the system performance when the grid of DVR is weak (Ho, et al., 2008; Ramasamy, et al., 2007). Flywheel Energy Storage as a preferred energy storage device, the system utilizes a single AC/AC power converter for the grid interface as opposed to a more conventional AC/DC/AC converter, leading to higher power density and increased system reliability (Wang, et al., 2009; Zhu, et al., 2008; Perez, et al., 2006). However the suitable of the type of energy storage depend on the DVR designed in term rated power and the total cost factor.

2.2.3 LC Filter:

Basically filter unit consists of inductor (L) and capacitor (C). The LC filter design procedure is discussed in (Dahono, et al., 1995). In DVR, filters are used to convert the inverted PWM waveform into a sinusoidal waveform. This can be achieved by eliminating the unwanted harmonic components generated by the VSI action. Higher orders harmonic components distort the compensated output voltage (Zhan, et al., 2000). The unnecessary switching harmonics generated by the VSI must be removed from the injected voltage waveform in order to maintain an acceptable Total Harmonics Distortion (THD) level. The switching frequencies of the VSI are usually up to several kHz for medium power level (Zhan, et al., 2001).
The passive filters can be placed either in the high voltage or in low voltage side winding of the series injection transformer (Agileswari, K., 2005). If the filter is installed at the low voltage side it has the advantage of being closer to the harmonic source thus high order harmonic currents are avoided to penetrate into the series injection transformer. Harmonics currents will circulate into the series injection transformer if the filtering scheme is placed at the high voltage (Newman, et al., 2005; Choi, et al., 2000).

2.2.4 Voltage Source Inverter (VSI):

The function of an inverter system in DVR is used to convert the DC voltage supplied by the energy storage device into an AC voltage (Ravi kumar, et al., 2007). Voltage source inverter (VSI) of low voltage and high current with step up injection transformer is used for this purpose in the DVR compensation technique (Perera, et al., 2006). Generally Pulse-Width Modulated Voltage Source Inverter (PWMVSI) is used transformer is used. Thus a VSI with a low voltage rating is sufficient (Zhan, et al., 2001). There are two basic three phase inverter topologies, the popular two-level inverter as shown in Figure 3.1 and the multilevel inverter as shown in Figure 3.2 (S.R. Ashcraft, et al., 1999), multilevel inverters have recently emerged as an attractive alternative to PWM schemes so that the losses associated with fast switching can be eliminated (S.R. Ashcraft, et al., 1999). The implementation of the PWM in the two level inverter is simpler and its cost is cheaper than a multilevel inverter.

![Fig. 3.1: Two level switch mode inverter (Ashcraft, et al., 1999).](image1)

![Fig. 3.2: Multilevel inverter (Loh et al., 2004; Ashcraft, et al., 1999).](image2)
2.2.5 By Pass Switch:
Fault current causes by faults in the downstream will flow through the inverter circuit of the DVR. Therefore to avoid high currents flowing to the inverter, a protection device namely by-pass (crowbar circuit) switch is used, which is incorporated to by-pass the inverter circuit. Normally the by-pass switch will be in active mode and senses the current flowing in the distribution circuit and if the current flowing over than the inverter current rating limit, the circuit bypasses the DVR circuit components in order to protect the inverter from over currents. The bypass switch will become in inactive when the source current is in rated value or in normal condition.

3. Operation of the DVR:
A typical DVR (Nielsen, et al., 2005) as shown in Figure 1 is used for voltage compensation in the distribution line. The operation of the DVR can be categorized into three operation mode as follows;
- Protection mode
- Standby mode and
- Injection mode

In protection mode scheme, the bypass switch can be used as a protection device to protect DVR from the over current in the load side due to short circuit on the load or large inrush currents (Ramachandaramurthy, et al., 2004). The DVR can be protected by the action of the bypass switches by supplying another path for current as shown in Figure 3.3(a).

![Fig. 3.3(a): The aspect of power switches.](image)

In standby mode ($V_{DVR} = 0$), as shown in Figure 3.3(b) the injection transformer’s low voltage winding is shorted through the inverter. No switching of semiconductors occurs in this mode of operation because the individual inverter legs are triggered such as to establish a short-circuit path for the transformer connection. Therefore, only the comparatively low conduction losses of the semiconductors in this current loop contribute to the losses. The DVR will be most of the time in this mode. In Jimichi, et al., 2008) discussed the operation of DVR during standby mode, two upper IGBT’s in each phase of the inverter remains turned off while the two lower IGBT’s turned on. A short circuit across the secondary (inverter side) windings of the series transformer through LF is obtained eliminating the use of bypass switches.

The DVR goes into injection mode ($V_{DVR} > 0$) as soon as the sag is detected (Fitzer, et al., 2004). Three single-phase ac voltages are injected in series with required magnitude, phase and wave shape for compensation, (Nielsen, et al., 2004). The types of voltage sags, load conditions and power rating of DVR will determine the possibility of compensating voltage sag. The DVR should ensure the unchanged load voltage with minimum energy dissipation for injection due to the high cost of capacitors. The available voltage injection strategies are pre-sag, phase advance, voltage tolerance and in phase method (Ramachandaramurthy, et al., 2004).
3.1 The DVR Location in the Distribution System:

Figure 3.4 represents a single phase model of the DVR. The DVR can be described as an ideal voltage source comprises of the reactive element $X_{DVR}$ in the injection transformer and line filter, and the value of the $R_{DVR}$ show the losses in the DVR. The impedance size of the DVR is related to the voltage and the power of the DVR.

The DVRs can be placed either at the Medium voltage (MV) or Low voltage (LV) level. In this thesis only discusses the proposed design of the DVR in low voltage distribution system. In both systems the main purpose is to inject a synchronous voltages during faults. A main different between a LV connection and a MV connection is the flow of zero sequences currents and the generation of zero sequence voltages. In the four wire system the DVR must secure a low impendence for zero sequence currents and the zero sequence must either flow in the power inverter or in a delta winding of the injection transformer (Nielsen, et al., 2000). Figure 3.5 (a) and (b) show the typical location of the DVR in medium and low voltage level. Medium voltage comprises of a three wire while in Low Voltage four wire system is used.
Fig. 3.5: Two type of the DVR location, (a) Medium voltage three wire (b) Low voltage four wire.

DVR application at low voltage distribution system as shown in Figure 3.5(b) has some advantages (Nielsen, et al., 2005) as follows;

- The DVR can be targeted more specifically at voltage sags sensitive loads.
A majority of electric consumers have only access to the low voltage level and the DVR can both be placed by the customer or utility.

The short-circuit level is significantly decreased by the distribution transformer and the DVR is easier to protect.

Figure 3.6 represents the intended location for the Low Voltage DVR four wires which is applied in the distribution system with 415 V line voltages. The basic of the Low voltage DVR is connected to the two level inverter with the main DVR parameters.

3.2 DVRs Topologies System in Distribution System:

As mentioned earlier the function of a DVR is maintaining the voltage supply at the load to its nominal value. There are so many DVRs topologies proposed by the researchers. In (Nielsen, et al., 2005) discussed two types of DVR topologies system comprising of no energy storage and with energy storage. Normally during disturbances in a network, the DVR injects an appropriate voltage to recover the voltage at the load. In this situation the DVR need to have exchanges active and reactive power with the surrounding system. Figure 3.7 shows the system topologies for DVRs consists of two types topologies system, namely no energy storage and with energy storage.

![System Topologies For DVRs](image)

Fig. 3.7: System Topologies For DVRs.

3.2.1 DVR Topologies with no Energy Storage:

Topologies with no Energy storage can be divided into two systems configurations which are system 1 and system 2. The different between System 1 and System 2 in DVR topologies with no energy storage is that, in system 1 the energy source is from the incoming supply through a passive shunt converter connected to the supply side as shown in Figure 3.7(a) means that the energy is taken from the grid connected side through a passive shunt converter connected to the source side. While in system 2 (Woodley, et al., 2000) energy is taken from the grid connected side through a passive shunt converter connected to the load side as shown in Figure 3.7(b). DVR topologies with no energy storage use the fact that a significant part of the source voltage continuous maintain during the disturbances, and this source can be used to provide the boost energy required to maintain full power at its nominal voltage.
3.2.2 DVR Topologies With Energy Storage:
The stored energy storage supplies the real power requirements of the system when DVR is used for compensation process when there is a disturbance in the distribution system. Flywheels, lead acid batteries, superconducting Magnetic Energy Storage (SMES) and supercapacitor can be used as energy storage devices. In voltage disturbances mitigation such as voltage sags the performance of the DVR can be improved by using energy storage even though storing electrical energy is expensive. System 3 as shown in Figure 3.8(a) is the topologies with energy storage where the variable DC-Link Voltage is used. The energy is stored in the DC-Link Capacitor. The type of this topology is considered as a simple topology and it can be running with a variable dc-link voltage. The energy storage required to activate the DVR is proportional to the square of the rated dc-link voltage (Nielsen et al., 2005). In system 4 Constant DC-Link Voltage is applied to this topology, as shown in Figure 3.8(b). Energy storage such as SMES, batteries or supercapacitors can be used as a direct energy storage which is applied in DVR. The large energy storage is then transferred to the smaller rated dc-link storage using an inverter during the disturbances in the network.
3.3 Type of Control Strategies in DVR:

In the literature survey (Chan, et al., 2006; Ezoji, et al., 2010; Marei, et al., 2007; Li, et al., 2007; Carl, et al., 2007) shows several techniques to implement and control philosophy of the DVR for power quality improvement in the distribution system. Most of the reported DVR systems are equipped with a control system that is configure to mitigate voltage sags/swells. Other DVR applications that include power flow control, reactive power compensation, as well as limited responses to power quality problems. The aim of the control scheme is to maintain constant voltage magnitude at the point where a sensitive load is connected under system disturbances. The control system only measures the r.m.s voltage at the load point, i.e., no reactive power measurements are required. The control of DVR is very important and it involves detection of voltage sags (start, end and depth of the voltage sag) by appropriate detection algorithms which work in real time. The voltage sags can last from a few milliseconds to a few cycles, with typical depths ranging from 0.9 p.u to 0.5 pu of a 1-pu nominal (Zhan, et al., 2001; Banaei, et al., 2006). Inverter is an important component of DVR. The performance of the DVR is directly affect to the control strategy of inverter. There have many studied been
The researchers have developed inverter control strategies for the DVR implementation. The inverter control strategies used in DVR recently is shown in Figure 3.9.

**Fig. 3.9:** Inverter control strategy of DVR.

The inverter control strategy comprises of two types of control as following:

1. **Linear Control**
   - Linear control is considered as a common method of DVR control. Amongst the linear control been used in DVR are feed forward control, feedback control and composite control. Feed forward control is a simple method of DVR (Zhang, et al., 2000; Woodley, et al., 1999; Chi-Jen, et al., 2003; Han, et al., 2002). The feed forward control technique does not sense the load voltage and it calculates the injected voltage based on the difference between the pre-sag and during-sag voltages. The feedback control strategy measures the load and the difference between the voltage reference of the load and actual load voltage is injected voltage required (Huang, et al., 2002). The feedback control methods based on state space systems, which can be set up closed-loop poles in order to make faster time response is also discussed in (Wenyong, et al., 2007). Both the feed forward and the feedback control strategy may be implemented by scalar or vector control techniques. Double-loop feedback control method with outer ring voltage and inner current ring have been discussed in (Vilathgamuwa, et al., 2002; Xueson, et al., 2007; Nielsenj, et al., 2004; Hui, et al., 2004). Composite control strategy is a control method with grid voltage feed forward and load side voltage feedback, which has the strengths of feed-forward and feedback control strategy, so it can improve voltage compensation effect. An improved control method has been proposed in reference (Meng, et al., 2005). If the feedback control in the composite control is designed to double-loop, it can improve system stability, system performance and the adaptability of dynamic load. The combination with feed forward control can improve the system dynamic response rate, shortening the time of compensation significantly (Vilathgamuwa, et al., 2002). The control method with inductor current feedback and feed forward load current is designed without series transformers thus the size and cost of a DVR can be reduced is implemented in (Sngek, et al., 2004).

2. **Non Linear Control**
   - Due to the usage of power semiconductor switches in the VSI, then the DVR is categorized as non-linear device. In case of when the system is unstable, the model developed does not explicitly control target so all the linear control methods cannot work properly due to their limitation.
(a): Artificial Neural network Control (ANN):
One of the non-linear method control is Artificial neural network control (ANN) and it equipped with adaptive and self organization capacity. ANN control can monitor the non linear relationship based on input and output without the detail mathematical model. Normally ANN control can be classified into feed forward neural networks, feedback neural network, local approximation neural networks and fuzzy neural network based on structure. Control system using ANN control is implemented in (Jurado, et al., 2004).

(b): Fuzzy Control:
Fuzzy logic control of DVR for voltage injection is reported in (Bayindir, et al., 2007). Its design philosophy deviates from all the previous methods by accommodating expert knowledge in controller design. It is derived from fuzzy set theory introduced by (Zadeh, 1965). FL controllers are an attractive choice when precise mathematical formulations are not possible. In (Jurado, et al., 2004) discussed about the implementation of FL in DVR. The advantages of this controller is capability to reduced the error and transient overshoot of PWM.

(c) Space Vector PWM (SVPWM) control:
Space Vector PWM (SVPWM) control strategy used in AC motor variable speed drives by the Japanese scholars in the early 1980s. The main idea is to adopt a voltage inverter space vector of the switch to get quasi-circular rotating magnetic field instead of the original SPWM, so better performance of the exchange is gained in low switching frequency conditions.

A double-loop vector control has been proposed in reference (Awad, et al., 2004). To simplify the calculation, the theory PQR instantaneous power directly to the geostationary coordinate system to transform the three-phase voltage PQR coordinates of the three direct traffic has been proposed in reference (Lee, et al., 2004).

Besides the types of these control, there is also available control for single phase sag detection methods used in DVR. Soft Phase Locked Loop (PLL) (Hangzhou, et al., 2008). Mathematical Morphology theory based low-pass filter (Zhou et al., 2008), Instantaneous Value Comparison Method (Bae, et al., 2007) are commonly used control for single phase voltage sag detection in the distribution system.

3.3 The Concept of Compensation Techniques in DVR:
Figure 3.10 shows the concept of compensation techniques which is applied in DVR, can be divided into two categories as follows;

i) The reactive power compensation

ii) Active and reactive power compensation

![Fig. 3.10: The Compensation Technique of A DVR (H. Awad, et al., 2003; Nielsen, et al., 2001)](image)

The methods for injection of missing voltage can be elaborated into pre sag compensation, in-phase compensation and phase advance or minimum energy compensation (Chung, et al., 2007; Ezoji, et al., 2009). The details of the of the pre-sag and in-phase compensation can be found in (Nielsen, et al., 2001) whereas minimum energy compensation is discussed widely in (Vilathgamuwa, et al., 2003).
3.3.1 Pre-Sag Compensation:
In Pre-Sag compensation, it is important for both magnitude and the phase angle to be compensated. The
difference between the pre-sag and during the sag voltage are detected by the DVR and it injects the different
voltage. Therefore, the amplitude and the phase of the voltage before the sag has to be exactly restored (Zhan, et al.,
2002). Figure 3.11 illustrates the pre-sag compensation technique showing before and after the voltage sags.

![Pre-sag Compensation Diagram](image)

**Fig. 3.11**: Pre-sag compensation showing before and after the voltage sag.

3.3.2 In-Phase Compensation:
In-Phase Compensation technique, the injection voltage is in phase with the source voltage (Margo, et al.,
2007). When the source voltage is drop due to sagging problems in the network the injection voltage produced
by the Voltage Source Inverter (VSI) will injects the missing voltage based on the drop voltage magnitude. This
method can be shown in Figure 3.12.

![In-Phase Compensation Diagram](image)

**Fig. 3.12**: The diagram of In-Phase Compensation Technique.

3.3.3 Reactive Power Compensation:
In the reactive power compensation only small energy storage is required in the other word this concept
does not require any active power. The phasor diagram of the reactive power compensation is illustrated in
Figure 3.13 (C.S. Chang, et al., 2004) in this compensation method the DVR providing reactive power
compensation does not require any active power as it can be observed in the figure, the injected voltage is
quadrature with the load current.

![Reactive Power Compensation Diagram](image)
Conclusion:
A comprehensive study of a DVR as a powerful custom power device has been presented in this paper. The main function of a DVR is the protection of sensitive loads from voltage disturbances coming from the network. The types of voltage disturbances such as voltage sags or swells, transients, unbalanced voltage and harmonics. The existing topologies and its controllers applied in DVR have been elaborated with detail. This study also gives useful knowledge for the researchers to develop a new design of DVR for voltage disturbances in electrical system. From the literature survey of DVR applications we can concluded that the trends of DVR through the years are still assumed as a good area.

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