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Review on AC–AC Converter Based Dynamic Voltage Restorer

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Abstract

The maintain power quality is one of the major part of all kind of industry as well as power systems. Voltage sag and voltage swell the common power quality issue. The Dynamic Voltage Restorer is the common Device which is used to mitigate the above problems. In this paper provides review on various type of AC-AC converter based DVR. The use of AC-AC converter can compensate the voltage sag and swell without need of any kind of storage elements like capacitor and batteries. The absence of storage elements can reduce size and weight of the DVR. The feature various type of AC- AC converters based DVR is concentrated in this paper.

Key Words: *Dynamic Voltage Restorer, power quality, AC-AC converter*

1. Introduction

The various power quality problems are due to the increasing use of nonlinear loads like power electronic loads. Voltage disturbance and harmonics occur due to these loads. The malfunctioning of sensitive equipment will causes due to power quality problems. The production and relay system will get operate during unsuitable time [1]. Distribution system is mostly affected by voltage sag and swell power quality issue. Short circuits, Lightning strokes - faults and inrush currents are the main sources of voltage sags. Stop / Start of heavy loads, badly dimensioned power sources, poorly regulated transformers, single line to ground fault on the system lead to voltage swells. Voltage sag is a decrease of the normal voltage level between 10 and 90% of the nominal RMS voltage at the power frequency, for durations of 0,5 cycle to 1 minute. Voltage swells are momentary increase of the voltage, at the power frequency, outside the normal tolerances, with duration of more than one cycle and typically less than a few seconds [2-5].

The use of Dynamic Voltage Restorer is one of the most effective methods to mitigate voltage sag and swells. Custom Power Device (CPD) is a powerful tool based on semiconductor switches concept to protect sensitive loads if there is a disturbance from power line [5-7]. Among the several novel CPD, the Dynamic Voltage Restorer (DVR) are now becoming more recognised in industry to compensate the impact of voltage disturbances on sensitive loads Power quality in the distribution system can be achieved better by using a custom power device DVR for voltage disturbances such as voltage sags, swells, harmonics, unbalanced voltage and etc. The Dynamic Voltage Restorer (DVR) is a device that identifies the sag or swell and connects a voltage source in series with the supply voltage in such a way that the load voltage is kept inside the established tolerance limits. The need of series connection is to add or subtract the voltage level [7-10].

2. Dynamic Voltage Restorer

Dynamic voltage restorer is a series connected static var device that has applications in a various transmission and distribution systems. The DVR is a series compensation device, which protects Power Quality from voltage sags, swells [11-15]. The first DVR was installed in North America in 1996 - a 12.47 kV system located in Anderson, South Carolina. Since then, DVRs have been applied to protect critical loads in utilities, semiconductor and food processing. Today, the dynamic voltage restorer is one of the most effective PQ devices in solving voltage sag problems. The main function of DVR is to supply or suppress the voltage accordingly when the sag or swell is accrued with suitable magnitude and frequency, so that it can restore the

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load side voltage to the desired amplitude and waveform even when the source voltage is unbalanced or distorted. This can improve the cost efficiency. The DVR can achieve the compensation by two different ways one is to achieve by AC/DC/AC and another type can compensate by AC-AC conversion. Now a day the evaluation AC-AC converter can be implemented for the Dynamic Voltage Restorer. By a direct converter eliminate the dc link [15-20]. Energy storage makes the DVR unit bulkier and costlier. Also, the dc link imposes a limit on compensation capability of the DVR in terms of magnitude and duration of compensation. The AC-AC converter based DVR can eliminate the sag for unlimited durations.

3. Review on AC –AC Converter Based DVR

Bingsen Wang et al proposed a voltage sag controller using matrix converter connected with flywheel this this flywheel can generate the AC voltage. The PM machine run flywheel is chosen to be the energy storage based on the overall balance among the power density, efficiency, cost and environmental friendliness. Than AC voltage is used as injection voltage when the sag is produced.

System mainly need below requirement to produce the optimal compensation.

1. The stored energy and mitigate voltage sags is to be to maintain and recover from by Bidirectional power flow.
2. A the output of the converter power factor is to be maintained at high range in order to guarantee the system to function properly regardless of the nature of the load.
3. The converter should be operated in buck mode because in voltage sag condition the system need an only low range of power.

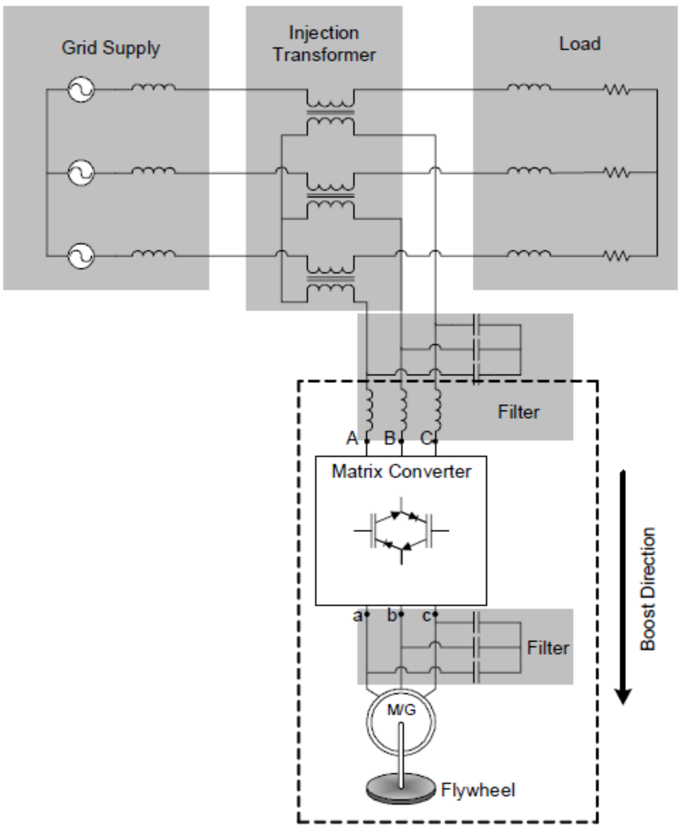

Figure 1. I Fly wheel Energy Storage based DVR proposed by Bingsen Wang

Flywheel is supply voltage then the capacitor is used to store the energy and it is act as source then the configuration including the inductor of the matrix converter, LC filter, filter capacitor across the machine so that converter going to boost mode configuration. To overcome the control design challenge, a non-linear input decoupling strategy is put forth which agrees application of classical servo-control design methodology to the reduced-order subsystem, namely the grid interface LC filter. To overcome the control design challenge, a non-linear input decoupling strategy is put forth which allows application of classical servo-control design methodology to the reduced-order subsystem, namely the grid interface LC filter. There are two controllers are used in this method one is to control the voltage for the injunction to the system and to control the speed of the flywheel during idling. Under the voltage unbalance in the system the flywheel requires to vary the speed according to the voltage level.

Jorge Pérez et.al introduced a single-phase AC-AC matrix converter which can compensate voltage harmonics and voltage regulation at critical loads terminals. The converter is composed with the only four number of switching devices and it's controller is working under the non-linear law

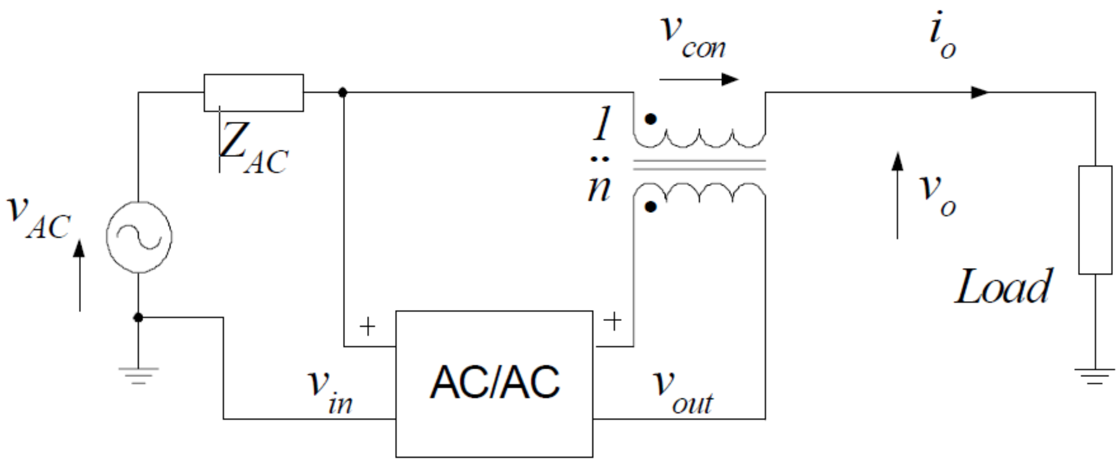

Figure 2. Single-Phase AC-AC Converter Operating as a Dynamic Voltage Restorer proposed by Jorge Pérez, et al

The single-phase matrix converter is fed in between the source and load the matrix converter is used to inject voltage in opposite direction to the fauled voltage. The generated voltage is injected by the coupling transformer obtaining a sinusoidal load voltage. The proposed topology operates as a buck AC-AC power converter to compensates the disturbances generated by the AC source. When the sag is appear in the system means the converter switching is in phase with the system voltage and when the swell is produced means the converter fired at 180 degree angle

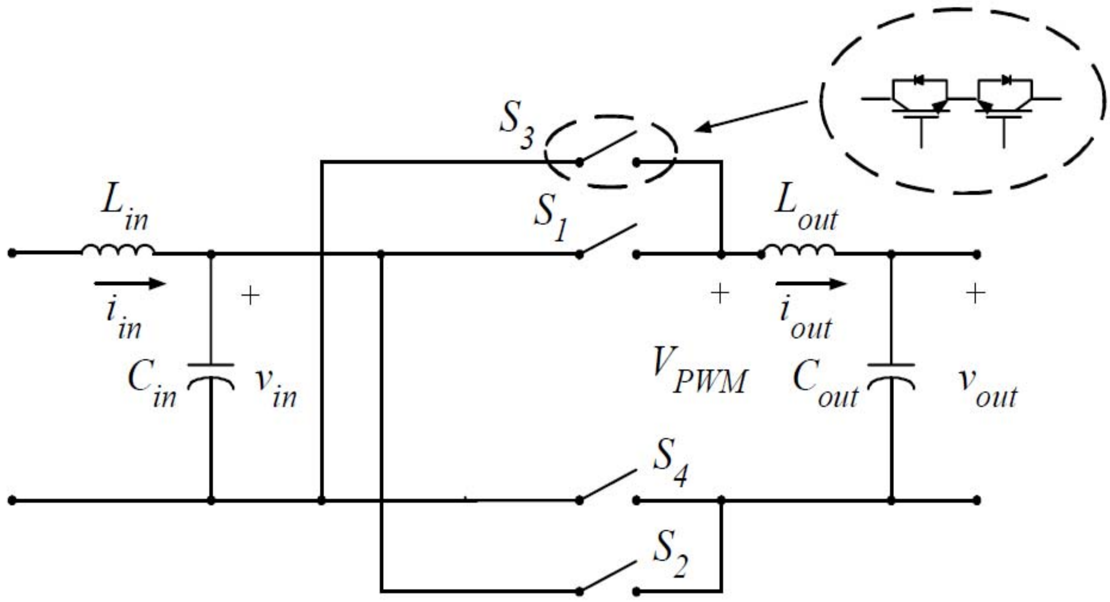

Figure 3. Single-Phase AC-AC Converter

One of the advantages in the proposed structure is that the coupling transformer does not require taps to change the polarity of the compensated voltage.

Suma Jothibasu et.al proposed a control scheme based on the characterization of voltage sag is proposed. Therefore, it aids in the flexible compensation by switching between presag and in phase compensation. The scheme provides 100% compensation for type B sag, and for all other types, compensation up to 50% sag magnitude with phase jumps ranging from 60 to -60 for interphase ac–ac topology. The algorithm takes; at most, half a cycle to compensate and it works in the presence of harmonics and unbalance, since the Fourier transform is employed to extract the fundamental component. A control scheme based on the characterization of voltage sag is proposed. It is tested on interphase ac–ac converter topology and it is found that the scheme

Therefore, it aids in the flexible compensation by switching between presag and inphase compensation. The scheme provides 100% compensation for type sag, and for all other types, compensation up to 50% sag magnitude with phase jumps ranging from 60 to 60 for interphase ac–ac topology.Besides compensation gives insight on the limits on compensation imposed by various sag types.

The secondary's of the isolation transformers are connected such that they add the output Voltages of the choppers and inject them. Deriving the injected voltage from two voltage sources facilitates the realization of the desired reference voltage with phase shift. In this scheme, compensation of fundamental quantities has been considered. In case of harmonics, fundamental components are extracted and compensated by the scheme.

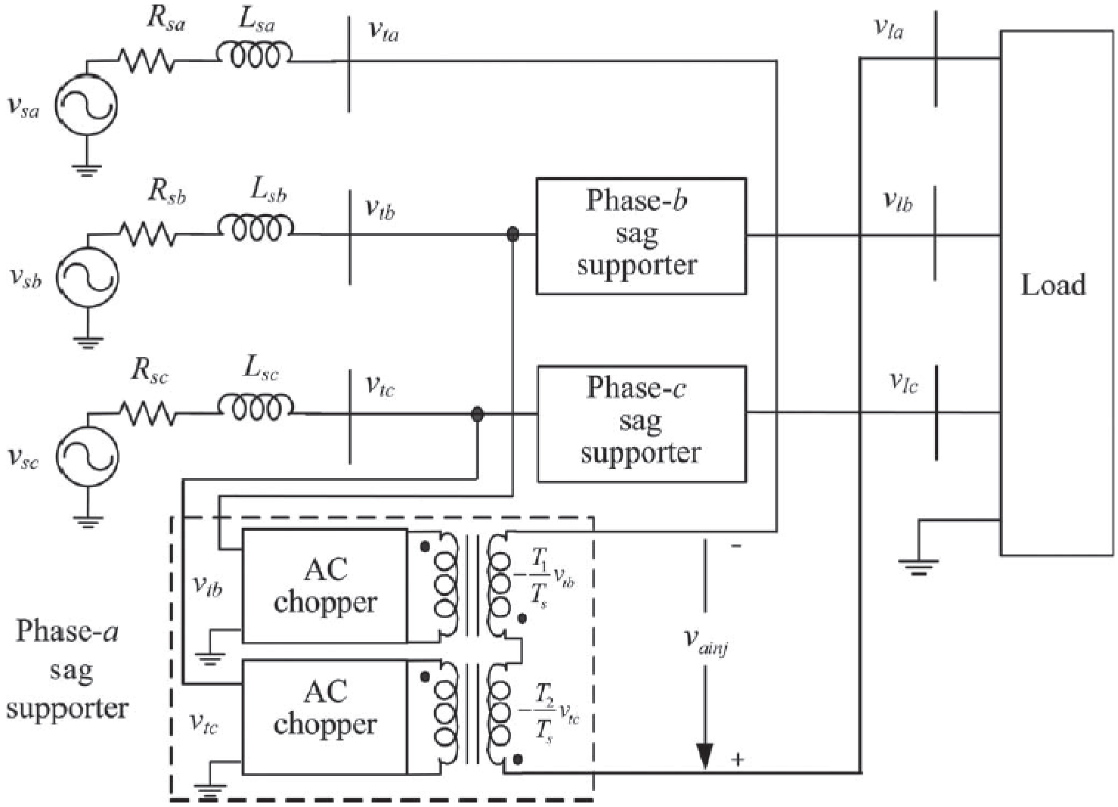

Figure 4. AC chopper fed voltage compensate proposed by Suma Jothibasu et al

Mahesh K. Mishra et al introduced an AC-AC-converter-based voltage sag supporter fed with line voltage has been proposed to compensate voltage sag with phase jump. The operation and switching logic of this topology are explained in detail. The capability of the topology is tested for different types of voltage sag and is compared with other topologies. This topology has the advantage of eliminating storage device and providing increased range of compensation. The ac–ac choppers in the sag supporters are fed with line voltages. Also, it retains the merit of the interphase topology by sharing the power drawn, from more than one phase at any instant of time.

The voltage sag supporter is provided between the PCC and the load. When a voltage sag occurs at the PCC of any of the phases, the corresponding sag supporter injects appropriate voltage in series with the supply voltage to maintain the desired load Voltage. Selector switches *S*1, $S1^I$, *S*2, and $S2^I$ are employed to select suitable line voltage input for thesecond ac chopper. Since the selector switches are operatedbased on a reference voltage, which does not significantly vary during a voltage sag event, the switches need not be operatedat higher frequency. Therefore, each sag supporter consists of four bidirectional switches operated at high frequency and fourothers at power frequency.

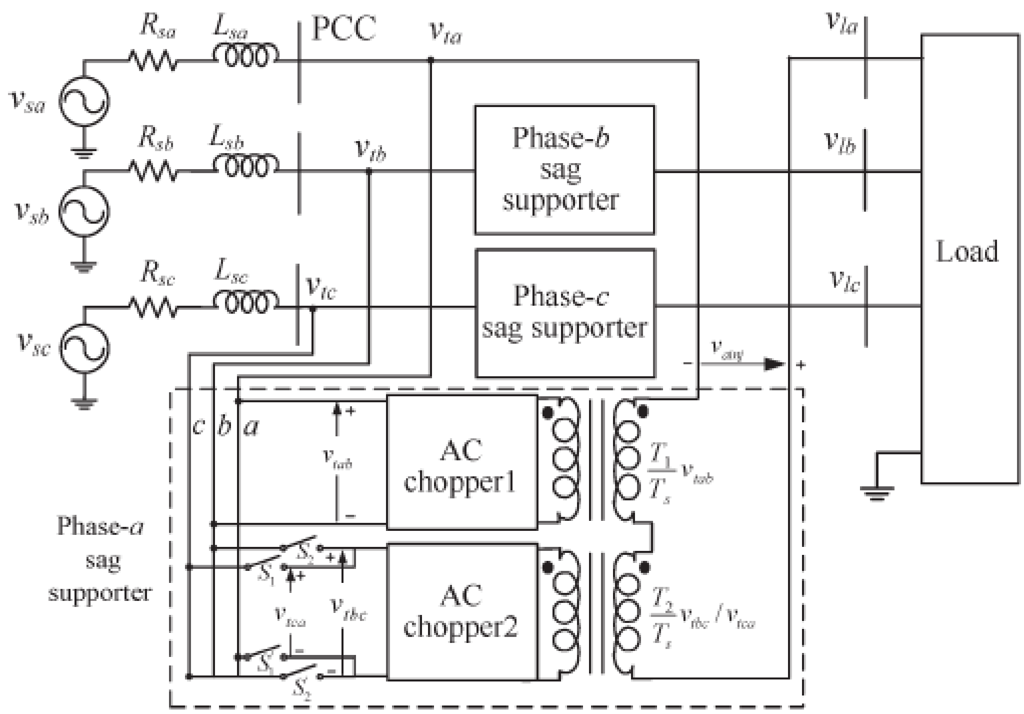

Figure 5. AC chopper fed voltage compensator proposed by Mahesh K. Mishra et al

Ebrahim Babaeiet.al concentrated onthe cost of this dc-link capacitor is high and it results in high cost and limited applications of DVRs. Therefore, some studies have been performed to reduce the size of the energy storage elements. There has been less attention to topologies of DVR that do not require any energy storage element. Like capacitor or any kind of battery.so it can compensate the unbalanced voltage as unlimited time interval the sag and swell both can be control by using this topology.

These topologies can compensate one phase outages because the compensation voltage in each phase is taken from all three phases of the source.

Ø is the phase angle of the injected voltage and is defined as follows:

Ø=0 for sag conditions

Ø=180 for swell conditions

Three phase to single phase converter is used in each phase. Considering Figure 3.5 the following equation can be obtained. At the normal condition the bypass switch V_{sb} are normally closed. At that time the converter is not connected to line so the normal voltage is appear on the line. The switching frequency is considered as F=$\frac{1}{t}$ and t is the sampling time and it is spiltted into two parts, and there are peak time and dead time.

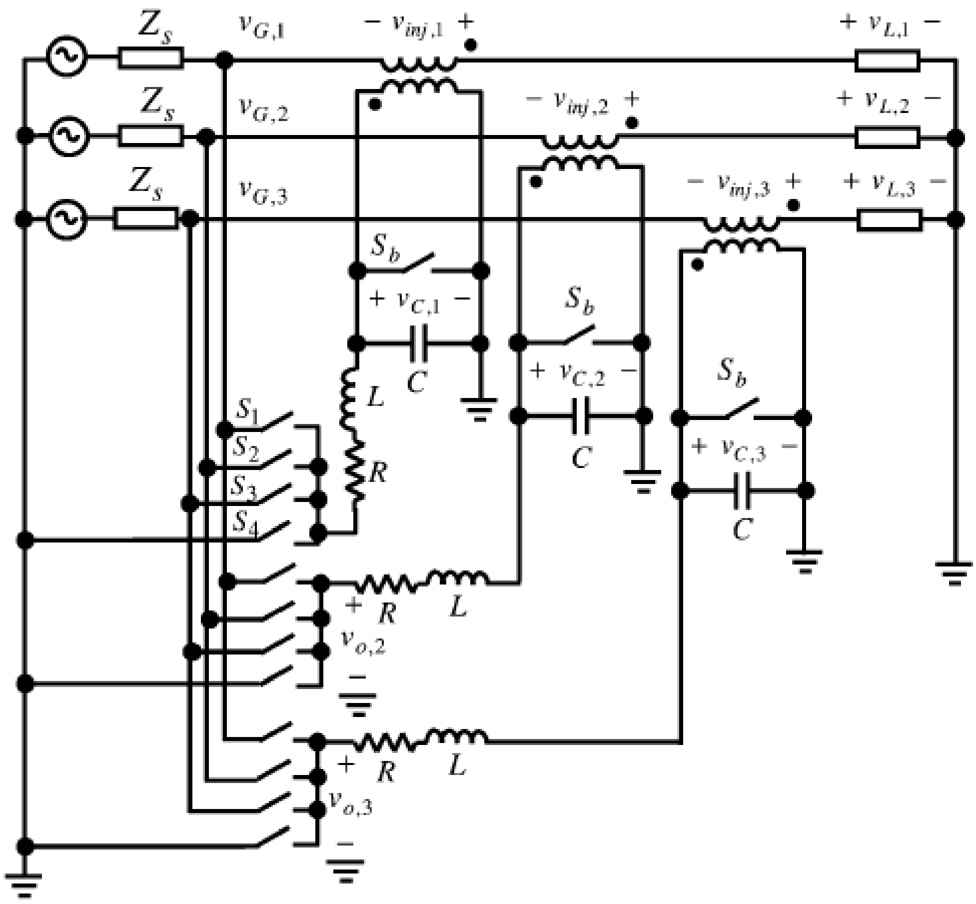

Figure 6. AC-AC converter based voltage compensator proposed by Ebrahim Babaei et al

The total time interval is obtained by adding peak and dead time interval. In the dead time interval, the zero voltage generation in three-phase-to-single-phase converter, switches output side will be turned on. Similarly, in the peak time interval, the switches that cause the maximum positive output voltage generation should be turned on if the converter output voltage is in its positive half cycle and reversely, the switches that cause a maximum negative output voltage generation should be turned on if the converter output voltage is in its negative half cycle. So during each sampling period, in the time interval and in the time interval, the zero voltage level will show up in the converter output and this will continue for all sampling periods.

Sag conditions the system voltage is to be added with injected voltage. When the Ø is 0 means the voltage is in phase with a DVR voltage and it can added with the system voltage, then sag can compensated. Swell conditions the system voltage is to be subtract with injected voltage. When the Ø is 180 means the voltage is out of phase with a DVR voltage and it can subtract with the system voltage, then the swell can be compensated. Therefore, if one phase of the source voltage has lost, the corresponding phase of the load can be supplied from the other two phases.

4. Conclusion

Now a day the power quality is major issue for the electrical systems. The voltage sag and swell is the most common problem in the power system. These problem also considered as serious problem. The evaluation AC –AC converter based DVR is helps to avoid the storage elements it can reduces the overall weight and cost of the system. This paper has revived the various type AC – AC converter based DVR. From the revive the AC-AC converter based DVR can compensate the voltage sag as well as swell without need of any storage elements. The absence of such elements can reduce the size and cost of DVR. These kind of DVR also compensate the voltage sag and swell with unlimited time durations.

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