

PERFORMANCE ANALYSIS OF DC SYSTEM USING RIPPLE ELIMINATOR TO IMPROVE POWER QUALITY

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Abstract - For dc systems, voltage/current ripples have emerged as a major power quality concern that could significantly impair performance on both the source and load sides and raise reliability issues. A single-phase pulse width modulation-controlled rectifier is used as an example in this suggested design to examine how active control techniques can enhance the power quality of dc systems, lessen voltage ripples, and simultaneously use fewer electrolytic capacitors. The ratio of capacitance reduction is measured, and the idea of ripple eliminators—which has been recently suggested in the literature—is expanded upon. In order to actively divert the ripple current on the dc bus, this power quality issue is formulated as a control problem with such ripple eliminators. This proposed design's primary goal is to examine how sophisticated control techniques might enhance ripple eliminators' performance. For one potential implementation of ripple eliminators in the continuous current mode (CCM), an advanced controller based on repetitive control is suggested. Results from experiments are shown to confirm the strategy's efficacy in comparison to another ripple eliminator that operates in the discontinuous current mode. It has been demonstrated that the suggested instantaneous ripple-current diversion in CCM improves performance by almost four times.

Key Words: Ripple Eliminator, AC to DC, IGBT.

1.INTRODUCTION

Proliferated renewable energy systems greatly promote the development of DC distributed power system, which enjoys flexible system configurations, high efficiency, and high density power delivery capability. In such DC systems, ripple power is often not a major concern because a DC current is constant and there is not an issue of phase differences between voltages and currents. However, in many applications like hybrid electrical vehicles and wind power systems, rectifiers and inverters are commonly used and DC voltages are not ideal but have a significant amount of harmonic components. Because of the harmonic components the voltages and the resulting ripple currents, ripple power has become a major power quality issue in DC systems. For systems powered by photovoltaic panels, batteries and fuel cells, large ripple currents and ripple voltages could considerably reduce the lifetime and long-term reliability of photovoltaic panels, batteries and fuel cells. During the charging mode of a battery, an external voltage with large

ripples could lead to an immoderate chemical reaction. During the discharging mode, ripple currents drawn from a fuel cell can degrade the system efficiency significantly and even make it unstable. Generally, current ripples should be maintained less than 10% of the rated current for batteries. In order to reduce the ripple current and smooth the external voltage on batteries and fuel cells, bulky capacitors or ultra-capacitor are often connected in parallel with them. Large electrolytic capacitors are also often needed to level and smooth the DC-bus voltage of inverters and rectifiers. For volume critical and/or weight-critical applications, such as electrical vehicles and aircraft power systems, the volume and weight of electrolytic capacitors could be a serious problem. Because of limited lifetime of electrolytic capacitors, they are one of the most vulnerable components in power electronic systems. According to, more than half of faults of static converters are caused by degraded electrolytic capacitors. On the other hand, the presence of large voltage ripples is an essential factor that accelerates the degradation of electrolytic capacitors. In a damaged UPS inverter assembly, the damage was caused by the ageing electrolytic capacitors. This may cause a big disruption in critical loads, which in turn could lead to a huge cost. As a result, in order to enhance the reliability of power electronic systems, it is highly desirable to minimize the usage of electrolytic capacitors and it is very attractive if highly-reliable small capacitors like film capacitors could be used to achieve low-level voltage ripples. However, in applications involving bulky electrolytic capacitors, it is often inevitable to have a tradeoff between minimizing the total capacitance required and suppressing voltage ripples. Another design degree of freedom, normally through active control, needs to be introduced to break this deadlock. In principle, this power quality issue in DC systems stems from energy fluctuation, which can come from sources and/or loads of systems. Four main approaches have been developed in the literature to reduce or compensate energy fluctuation so that the voltage ripples can be reduced and the power quality in DC systems can be improved. One approach is to inject harmonic currents to suppress the fluctuations of the input energy by changing the control strategy for the existing power switches in the system. In, it was proposed to inject third harmonic component to the input current so as to reduce the DC-bus capacitor in LED drivers. The analysis in these proposed designs is based on the fact that decreased pulsating input power leads to decreased ripple power and capacitor volume

on the DC bus, which can be achieved by controlling the input current. In a similar concept was also adopted by distorting the input current to reduce the output capacitor. The essence of injecting harmonic currents or distorting the input current is to obtain a varied duty cycle to control the power switches, which changes the amount of energy delivered to the load in each fundamental cycle. This approach benefits with no added power components but the disadvantage of this approach is the increased total harmonic distortion (THD) of the input current. The second approach is to use buck/boost DC/DC converters to construct two DC voltages across two capacitors that are connected in opposite polarity. The sum of pulsating energy stored in the two capacitors are nearly equal to the system pulsating energy and hence, the pulsated energy does not appear on the DC bus. Both the DC-bus voltage ripples and the required DC-bus capacitance can be reduced. The third approach is to add an active energy storage circuit in parallel with the DC-bus capacitor to bypass the ripple currents originally flowing through the DC-bus capacitor. The strategy proposed design is such an example, with a circuit consisting of one capacitor, one inductor and two power switches. It absorbs and releases the ripple energy, respectively, during its two different half cycles. Due to the particular operating modes adopted, the current is compensated in terms of averaged values, instead of instantaneous values, so the remaining voltage ripples are still large although considerably reduced. The fourth approach is based on connecting an active compensator in series with the DC bus line. The compensator basically behaves as a voltage source to offset the voltage ripples. Due to the series operation, the voltage stress of the added compensator is reduced. However, the current stress of the compensator is increased because the ripple power for a certain load is fixed. Due to the series connection, lines between the DC sources and loads should be cut off so that the compensator can be connected. However, for some DC systems, this can be a problem because of the widely-distributed sources and/or loads. Note that only the DC voltage after the compensator becomes clean without noticeable low-frequency ripples but the DC voltage before the compensator still suffers from large low-frequency ripples. Some of the aforementioned approaches are only effective in some specific DC systems while the others are applicable to different kinds of DC systems. For example, the method of injecting harmonics to mitigate pulsating power is specially designed for rectifier systems. In DC systems, there might be different kinds of widely-distributed sources and loads and hence, it is hard to apply this method to all sources and/or loads. From this point of view, it becomes obvious that the last two approaches are more effective to improve the power quality for general DC systems, although more power components are required. Compared to the fourth approach, i.e. adding a series eliminator, the third approach, i.e., adding a shunt eliminator, is more suitable for general DC systems because it does not need to cut off any lines for connecting eliminators. Shunt eliminators can be simply hooked onto the DC bus for the purpose of reducing voltage

ripples to improve power quality in DC systems. The main focus of this proposed design is to investigate how advanced control strategies could improve the performance of shunt ripple eliminators for DC systems, rather than optimizing the system performance through topological design. It is found that the capability of diverting the ripple current away from the DC bus is the key for improving the performance. Hence, it is important to adopt a control strategy that is able to track periodic signals and the repetitive control strategy is then applied to achieve instantaneous current tracking at a fixed switching frequency. Furthermore, it is preferred to operating the shunt ripple eliminator in the continuous current mode (CCM) rather than in the discontinuous current mode (DCM) because the current tracking is instantaneous in CCM but is in the average sense in DCM. Because the ripple current is diverted instantaneously in CCM, the voltage ripples can be reduced considerably.

1.1 Objectives

- The main objective of this implementation is design a single phase PWM rectifier and also reduce the ripples using ripple eliminator
- Reducing Usage of Bulky capacitors.
- Increase the life time of auxiliary Capacitor.
- To reduce the ripples.
- To Reduce the Total Harmonic Distortion.
- To increase the life time of the circuit.

1.2 Problem Statement

- In EV inverter systems, the dc-link capacitors are essential to provide reactive power, attenuate ripple current,
- Reduce the emission of electro-magnetic interference, and suppress voltage spikes caused by leakage inductance and switching operations.
- DC-link capacitors are bulky, heavy and expensive. One typical design comprises five electrolytic capacitors,
- Which are connected in parallel with the battery bank to supply an 80 kW motor drive system. Each capacitor is 9.4 cm in diameter and 14.6 cm in height. Since the five dc-link capacitors occupy more than 40% of the volume, the achievable PDV is limited to 2.99 kW/L

2. Proposed Methodology

- In order to facilitate the analysis in this proposed design, a single-phase H-bridge PWM-controlled rectifier as with all the components
- Assumed to be ideal to simplify the analysis in the sequel. Most of the findings can be easily applied to other applications.

- In order to break the deadlock between minimising the required capacitors and reducing voltage ripples,
- Another design degree of freedom, called the ripple eliminator, can be introduced to replace the bulky DC-bus capacitor,.
- The basic idea is to introduce an auxiliary capacitor C_a in the ripple eliminator so that the ripples on the DC bus can be transferred onto C_a .

Here in this proposed to use auxiliary capacitor with added ripple eliminator circuit, which will reduce ripples eliminator and size, usage of bulky capacitor by replacing it by auxiliary capacitor.

In our proposed added PWM based input strategy for rectification, which helps in reducing ripples as much as possible in initial conversion of AC to DC.

To reduce further we have used ripple eliminator circuit using IGBTs which will take input given by ripple control strategy blocks using PI and PWM method and auxiliary capacitors. This strategy actuators IGBT at proper time pulses which helps to reduce the ripple. Also our feedback loop assists in monitoring ripple.

3. RESULTS

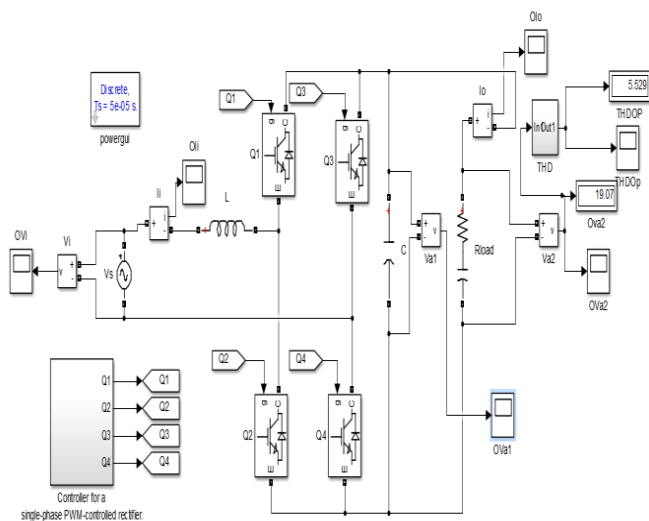


Fig-1: Circuit Without Ripple Eliminator

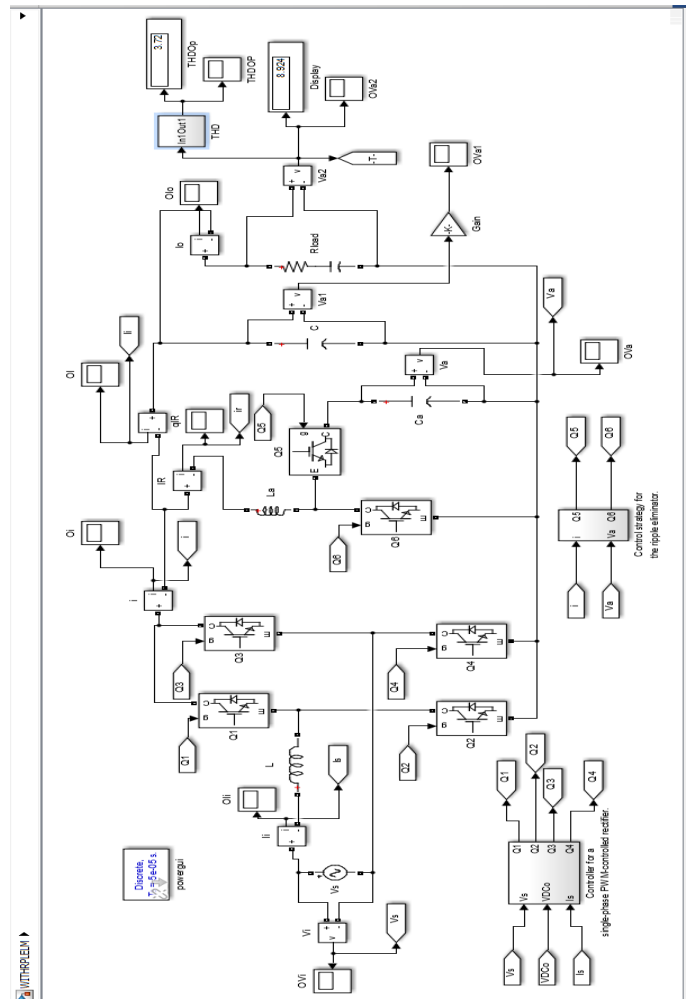


Fig-2: Circuit With Ripple Eliminator

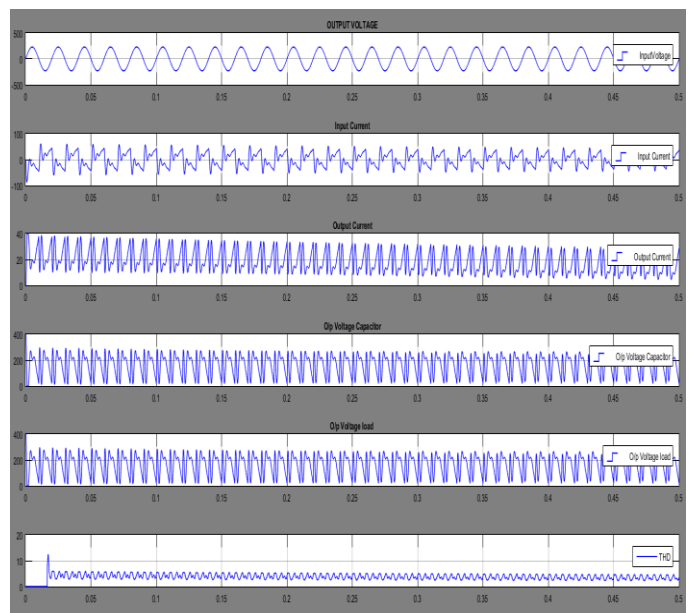


Fig-4: Output Waveform without Ripple Eliminator

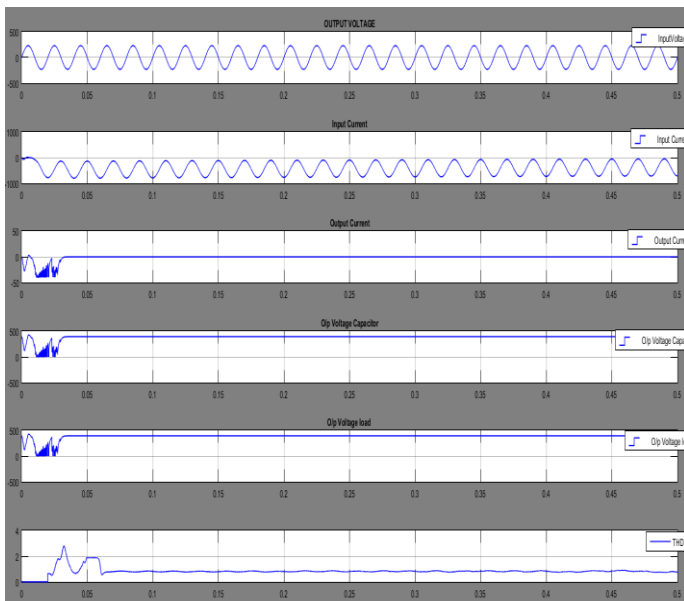


Fig -4: Output Waveform with Ripple Eliminator

As per the output screenshots displayed in the result window, now let us discuss about the results.

In Figure 3 Output current without Ripple eliminator is shown. And in figure 3 Output Voltage without Ripple eliminator across capacitor where we can clearly observe AC spikes in the DC output voltage. Also in Figure 3 the Output across the load also we can observe AC ripples in the DC voltage. And this is unacceptable as it causes loss and may damage devices.

So we have used Ripple eliminator circuit with control strategy with the help of PWM, Laplace and PI controller feedback using repetitive control method which reduces the ripples.

In Figure 4 we can observe that in the Output current waveform ripples are very less. Also in Figure 4 in the Output across the capacitor we can observe very less ripples and spikes in the DC output image.

Also in Figure 4 in the Output across the load we can observe very less ripples and spikes in the DC output image. And in Figure 16 we can observe that the Total Harmonic Distortion is also reduced.

So in overall in our methodology we have reduced the ripples and THD compared to existing methodology to a greater extent.

3. CONCLUSION

The concept of ripple eliminators has been further developed to improve the power quality and reduce the voltage ripples in DC systems and, at the same time, reduce the capacitance needed and the usage of electrolytic

capacitors. After deriving the reduction ratio of the capacitance required, the focus of this proposed implementation is on the design of an advanced control strategy so that the ripple current can be instantaneously compensated. It has been revealed that the capability of instantly diverting the ripple current away from the DC bus is the key to improve the performance. As a result, ripple eliminators that can be operated in CCM to instantaneously divert ripple currents are preferred; the repetitive control strategy is proposed to control one exemplar ripple eliminator, with the ripple energy provided by a single-phase PWM-controlled rectifier. It instantaneously compensates the ripple current on the DC bus so that the voltage ripples on the DC bus can be significantly reduced. It has been confirmed that it is important to operate ripple eliminators in CCM to instantaneously track the ripple current so that the DC-bus voltage ripples can be minimized to the greatest extent.

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