An Improved Ac to Dc Converter by Using Two Parallel Rectifiers for Dc Drives

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***Abstract*- This paper proposes a modified ac to dc converter composed of two parallel rectifiers, and a dc motor. The proposed topology permits to reduce the rectifier switch currents, the harmonic distortion at the input converter side, and presents improvements on the fault tolerance characteristics. Even with the increase in the number of switches, the total energy loss of the proposed system may be lower than that of a conventional one. The model of the system is drawn and it is shown that the reduction of circulating current is an important objective in the system design.**

Index Terms—Ac-dc power converter, drive system, parallel converter.

I.INTRODUCTION

Power consumption is rising day by day. In developed countries, power has been the fastest growing industry for the last decade. Many technologies are arising to develop power from various sources, which in turn produces a very high power using the advanced technologies. One of the methods for obtaining dc power is that to convert it from ac source. This technique involves power Electronics which is an advanced method to produce or control the voltage or current from the supply.

Several solutions have been proposed when the objective is to supply a Dc motors from a single-phase ac mains. It is quite common to have only an ac power grid in commercial, manufacturing, and mainly in traction. While the adjustable speed drives may request a Dc power grid. Ac–dc conversion usually employs a full-bridge topology, which implies in four power switches, as shown in Fig. 1.

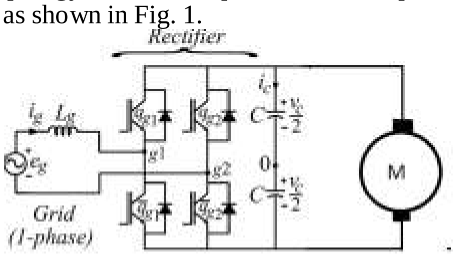

Fig. 1. Conventional drive system.

Converter is denoted here as conventional topology. Parallel converters have been used to improve t

of converters in parallel requires a transformer for isolation. However, weight, size, and cost associated with the transformer may make such a solution undesirable. When an isolation transformer is not used, the reduction of circulating currents among different converter stages is an important objective in the system. In this paper, ac to dc drive system composed of two parallel rectifiers and a dc motor is proposed. as shown in Fig. 2.

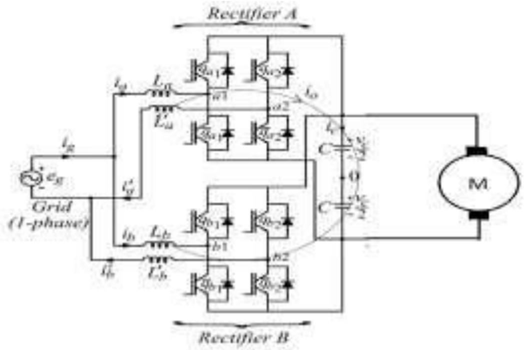

Fig. 2. Proposed Drive System

Compared to the conventional topology, the proposed system permits: to reduce the rectifier switch currents; the total harmonic distortion (*THD*) of the grid current with same switching frequency or the switching frequency with same *THD* of the grid current; and to increase the fault tolerance characteristics. In addition, the losses of the proposed system may be lower than that of the conventional one. The mentioned benefits justify the initial investment of the proposed system, due to the increase of number of switches.

II.RATING OF SWITCHES

For balanced system ($L = L_a = L_g = L_b = L$) voltage v_o is close to zero,Since the parallel connection scheme permits to reduce the switch currents and preserve the dc-link voltage, the rating of each power switch in the rectifier side is reduced.[1]

III.DC LINK CAPACITOR

Two dc link capacitors are used in proposed topology. They are connected in series as shown in fig.2.the ac voltage is rectified through parallel rectifier and it is provided to dc motor through dc link capacitor. They are are used for smoothing operation of dc motor drive.as denoted each capacitor gives half of required output voltage.[1]

IV.INPUT INDUCTOR

When the input inductors of the proposed topology ($L_{\_g}$) are equal to that of the conventionaltopology (L_g), the reduction of the *THD* of the grid current is possible because it act as a filterThe harmonic distortion of the rectifier currents (i_a , $i_{\_a}$, i_b, $i_{\_b}$,and i_o) is higher than that of the grid current i_g . The adequate choice of the PWM strategy and interleaved technique[ ] permits to operate with minimum harmonic distortion. We have considered the losses as the main concern to define the maximum acceptable harmonic distortion of the rectifier currents. In any case, the use of additional common-mode inductors is a very efficient manner of reduce the harmonic distortion of these currents [1]. This approach may be also employed in the present case to reduce the total inductance required for an adequate operation of the system. The design of inductors may follows the guide lines presented in [4] for an active power filter system.

V.FAULT COMPENSATION

The proposed system presents redundancy of the rectifier converter, which can be useful in fault-tolerant systems. The proposed system can provide compensation for open-circuit and short-circuit failures occurring in the rectifier. The fault compensation is achieved by reconfiguring the power converter topology with the help of isolating devices (fast active fuses) and connecting devices as observed in Fig. and discussed . These devices are used to redefine the post-fault converter topology, which allows continuous operation of the drive after isolation of the faulty power switches in the converter. presents the block diagram of the fault diagnosis system. In this figure, the block fault identification system (FIS) detects and locates the faulty switches, defining the leg to be isolated. Redundancy includes proper operation of healthy converter when fault or failure occurs on another converter. This way, four possibilities of configurations have been considered in terms of faults:

1) pre-fault (“healthy”) operation [see Fig.3a];
2) post-fault operation with fault at the rectifier B [see Fig. 3b];

VI.LOSSES AND EFFICIENCY

The evaluation of the rectifier losses is obtained through regression model presented in [1]. The switch loss model includes:

1) IGBT and diode conduction losses;

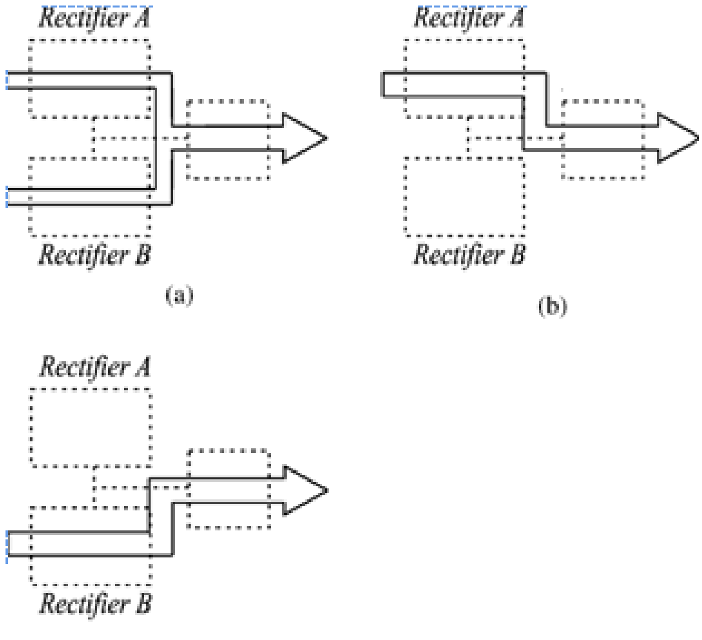

Fig.3 Possibilities of configurations in terms of fault occurrence. (a) Pre- fault system. (b) Post-fault system with fault at the rectifier B. (c) Post-fault system with fault at the rectifier A.

2) IGBT turn-ON losses;
3) IGBT turn-OFF losses; and
4) diode turn-OFF energy

The loss evaluation takes into account just the rectifier circuit, since the inverter side of converter is the same for the proposed and standard configurations. When the rectifiers operate with a proper switching frequency , the conduction and switching losses of the proposed topology were 70% and 105%, respectively[1], of the corresponding losses of the conventional topology. Consequently, in this case, the total losses of the proposed topology was smaller than that of the conventional topology. The increase of the switching frequency does not change the conduction losses of both topologies, but increases their switching losses, especially for the proposed topology that has a high number of switches. the proposed configuration with parallel converter presents higher efficiency than the conventional one.

VII. COSTS AND APPLICATIONS OF CONFIGURATION

The initial investment of the proposed system is higher than that of the standard one, since the number of switches and devices such as controlled rectifier is highest. But, considering the scenario when faults may occur, the drive operation need to be stopped for a non-programmed maintenance schedule. The cost of this schedule can be high and this justifies the high initial investment inherent of fault-tolerant motor drive systems. On the other hand, the initial investment can be justified if the *THD* or losses of the conventional system is a critical factor. Furthermore, the cost of power switches has decreased substantially . This permits to employ extra switches without increasing the final price of converter dramatically. The proposed system can be used in the same applications as the conventional configuration (traction), especially when the *THD* of the grid current, fault tolerance and efficiency of converter are critical issues.

. VIII. Configuration with increased no. of components

An increase in the number of components in dc converter is acceptable when benefits can be incorporated to the converter itself, as in the case of interleaved [3] or multilevel configurations [2], which improve the quality of power converter, the component count increase can be further justified by the need of the dc-link voltage fluctuation reduction. The main advantage of the proposed system

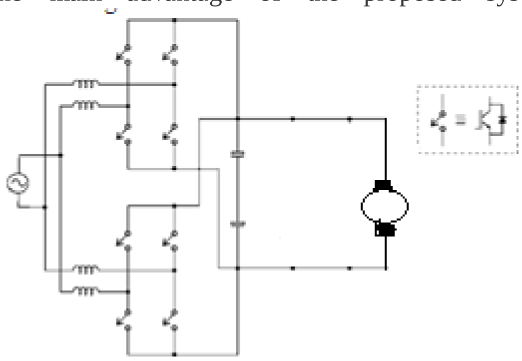

Fig.4 . Double rectifier stage

proposed circuit is that it does not require a large reactor and large smoothing capacitors in the dc-link part.

On the other hand, the converter permits the equal distribution of current among the semiconductor devices of the input and output converter sides (see Fig. 2). The conventional configurations (see Fig. 1) require rectifier power switches with current and power ratings larger than those switches in the proposed one .

In spite of increasing the number of components, such topology presents the following merits: 1) reduction of the rectifier current; 2) THD improvement in the grid side due to interleaved technique; and 3) reducing of stress in the dc-link capacitor and fault tolerance capability in the rectifier circuit. A circulating current appears in the rectifier stage, due to parallel connection, which is controlled and reduce by proposed system in.

shows some experimental results for configuration highlighting the interleaved operation. Fig., shows respectively, grid and rectifiers currents,

With the same philosophy, Jacobina *et al.* [1] propose a single-phase to three-phase converter composed of two parallel single-phase rectifiers and a shared leg between the input and output converter sides. In traction applications this circuit presents the following characteristics: 1) reduced power rating of the rectifier switches, which means switches operating at equivalent power rating; 2) reduced costs if the price of switches with different power ratings is higher than the cost of switches with close ratings; and 3) fault tolerance in the rectifier circuit. Other solution employing parallel connection of the ac–dc converter was presented by Jacobina*et al.* [1]; this configuration is depicted in Fig.4

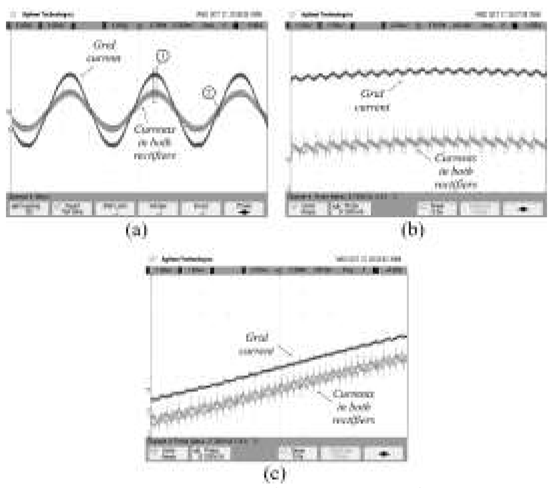

Fig. 5. Experimental results of the double rectifier stage proposed in [1]

IX .Interleaved Technique

Paralling of converter power stages is a well known technique that is often used in high-power applications to achieve the desired output power with smaller size power transformers and inductors . In addition to physically distributing the magnetics and their power losses and thermal stresses, paralleling also distributes power losses and thermal stresses of the semiconductors due to a smaller power processed through the individual paralleled power stages. . As a result, paralleling is a popular approach to eliminating "hot spots" in power supplies. Besides, the switching frequencies paralleled lower power stages may be higher than the switching frequency of the corresponding single high-power processing stage because lower power faster semiconductor switches can be used in implementing the individual power stages. Consequently, paralleling also offers an opportunity to reduce the size of the magnetic components.

The interleaving technique can be viewed as a variation of the paralleling technique, where the switching instants are phase shifted over a switching period . By introducing an equal phase shift between the paralleled power stages, the output-filter-capacitor ripple is lowered due to the ripple cancellation effect . As a result, the size of the output-filter capacitance can be minimized. Generally, the interleaving in topologies with inductive output filters can be implemented in two ways. One interleaving approach is to directly parallel the outputs of the individual power stages so that they share a common output-filter capacitor (the two-choke approach) . The other approach is to parallel the power stages at the input of a common output filter (the one-choke approach).[3]

XIII. CONCLUSION

A dc drive system composed of two parallel single- phase rectifiers, and an dc motor was proposed. The system combines two parallel rectifiers without the use of transformers. The system model and the control strategy, including the PWM technique, have been developed.

The complete comparison between the proposed and standard configurations has been carried out in this paper. Compared to the conventional topology, the proposed system permits to reduce the rectifier switch currents, the *THD* of the grid current with same switching frequency or the switching frequency with same *THD* of the grid current and to increase the fault tolerance characteristics. In addition, the losses of the proposed system may be lower than that of the conventional counterpart. The initial investment of the proposed system (due to high number of semiconductor devices) cannot be considered a draw-back, especially considering the scenario where the cited advantages justify such initial investment.

The experimental results have shown that the system is con- trolled properly, even with transient and occurrence of faults.

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