Commutation Failure In Converters - A Survey

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Abstract

This paper dispenses the literature review of various structures and strategies employed for solving commutation problems in ac-ac converters, inverters, rectifiers and also derives new topologies for dc-dc converters. The topologies adopted employs coupled inductors and switching cell structure to rectify commutation problems without using snubber circuits and ensures safe commutation. The presented papers conveys the causes of commutation and the solution employed with their own boon and bane. The selection of suitable converter with low switching losses, no shoot-through problems, less distortion, high quality desired waveforms, no dead-time issues are also important. Efforts have been taken to improve the authenticity and reduce the cost of converter. The appropriate power converter can be chosen depending on the application employed. Simulation results for some of the existing and proposed topologies are shown in this paper.

Key words: commutation, shoot-through, reliability, PWM technique

Introduction

There are several types of converters employed which depends on their respective platform on which they are going to be implemented. For constant frequency application ac-ac voltage controller can be used. For frequency changing applications, ac-ac matrix converter or cycloconverter can be used. For converting fixed voltage to variable voltage(depending on the type of supply), ac or dc choppers are employed. Likewise various converters are chosen based on the area of application. Most of the power electronic converters having switches exhibit commutation issues. Commutation issues occurs because of the time delay in switching, variation in switching speed, mistriggering, etc. The commutation issues can be rectified by choosing safe commutation strategies or employing bulky and lossy snubber circuits. The converter should be less complex , cost efficient and reliable. In order to satisfy these criteria certain techniques are adopted. This paper presents various converter topologies and PWM techniques to eradicate the commutation issues.

Various Converter Topologies:

1. Matrix converter [1,4]:

The single - phase matrix converter is employed for frequency changing applications as mentioned in [1]. The matrix converter replaces the conventional rectifier fed inverter systems topology due to reliability issues. The current is commutated using the dead-time technique in this converter. The control strategy used is the space vector modulation. Also the PWM dead time technique is used for soft commutation. The distinct quality of the proposed commutation strategy is that it suppresses the current vibrations in the machine (no damping circuit required) and has low THD. It is complex to define the time cycle of safe commutation and there are no freewheeling diodes available.

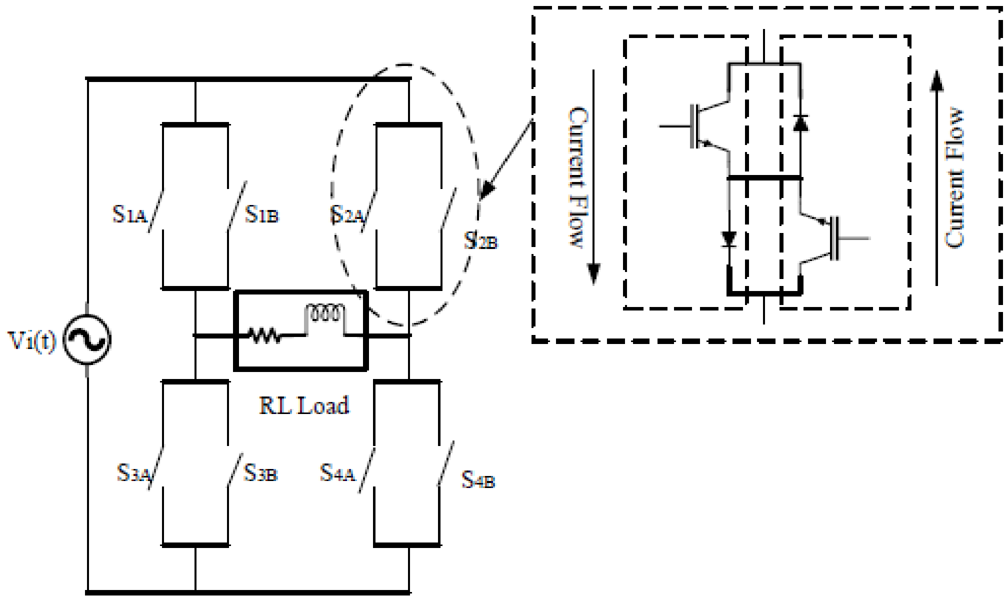

Fig 1. Circuit configuration of single phase matrix converter

2. A hybrid line commutated converter (LCC) and modular multi-level converters (MMC) [2-3]:

The commutation problem is prevalent in this system when the line commutated converter is operated as an inverter. However to overcome this drawback, the LCC is employed as a rectifier and MMC as the inverter to reduce the cost, power loss and commutation issues as explained in [2]. The commutation failure can be eradicated by adding additional devices but this in turn increases the cost and power loss. So suitable control strategy has to be adopted by identifying suitable extinction angle. The strategy adopted can only resist commutation failure but cannot completely eliminate it. The circuit breaker protection technique is also explained in this paper. In paper [3] they have explained the two phenomenon to be considered while predicting the occurrence of commutation failure . The voltage and current modulations are considered to calculate extinction angle to predict the commutation failure.

3. Dual Buck Inverter [13-14, 16-18, 20-21]:

In the paper [14] they have introduced a configuration to convert 2-wire to 3-wire mode in micro grid through neutral line. This method can reduce shoot through problem and can balance voltage. The quality of power in micro grid and flexibility of power supply is improved in this configuration. Shoot through problem is reduced by letting the freewheeling current to flow through independent freewheeling diodes. The above mentioned inverter with appropriate control strategy as mentioned in [17], doesn't need dead hence no shoot-through problem in it. This system employs hard switching. In paper [18,21], the shoot through problem is eliminated by letting the freewheeling current to flow without any obstacles. The current flows through the diodes thereby removing shoot through problem. Thus the loss of diodes can be reduced. Hysteresis current control technique is adopted to enhance efficiency. The circuit diagram of the inverter adopting hysteresis control is shown in Fig 2.

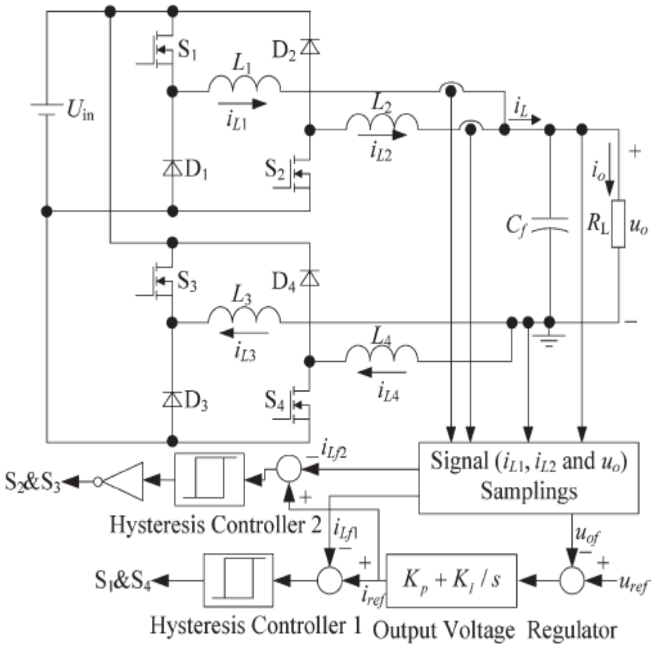

Fig 2. Circuit of DBFBI using hysteresis controller

4. Multilevel converter [26-27]:

In the paper [26], coupled inductor and pulse width modulation switching topology together helps in improving the number of voltage levels in VSI. In this system, the PWM frequency is increased with respect to switching frequency. The proposed inverter topology improves the quality of PWM waveforms thereby eliminating dead-times. The proposed multilevel single phase inverters with coupled inductors is shown in fig 3. Multilevel PWM voltage produced using coupled inductors is explained in [27]. The proposed topology makes use of cancelling the ripple current technique in order to attenuate the current distortion in the input side.

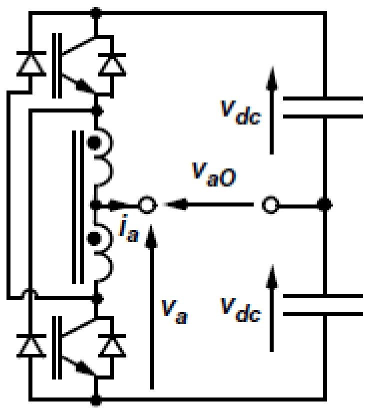

Fig 3. Multilevel single phase inverter using coupled inductors

5. DC-DC converters [23-24,28]:

In [28] various topologies using switching cell structure is explained. Out of P-cell and N-cell configurations, the N-cell configuration is preferred as they produces reduced output voltage ripple. It has been concluded that the N-cell circuit is advantageous. In [23-24], various dc-dc converters are reconfigured with switching cell structure. For example the dc-dc buck converter reconfigured as given in fig 4. The power converter adopted with any one of the above configurations reduces the shoot-through problem as the configuration has a switch and a diode in series instead of two switches in the same leg.

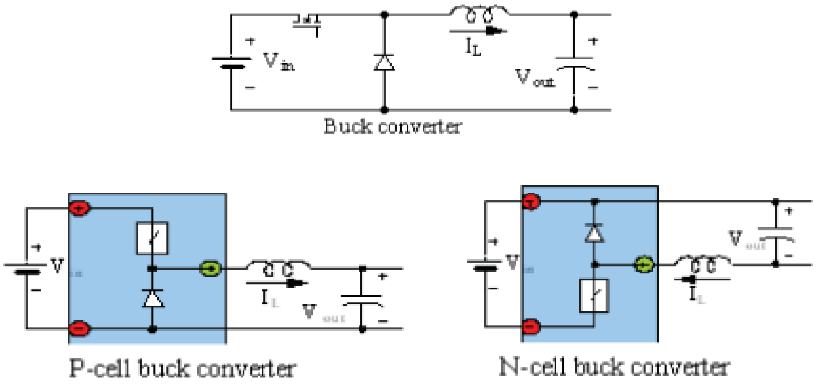

Fig 4. Reconfigured buck converter with switching cell topology

6. AC-AC converters [31-32]:

In [31], they have suggested various configurations of ac-ac converters. The main advantage of this system is that they use minimal of two switches thereby reducing the cost and increasing the reliability. This PWM control of ac-ac converter is utilized for voltage regulation. This configuration can be used for variable voltage and frequency applications. Also in [32] they have highlighted the advantages of ac chopper over ac controller. The commutation problem is reduced by selecting suitable fashion of gating pulses which in turn depends on the polarity of voltage.

<u>Simulation Results:</u>

The simulation results of the proposed ac-ac buck-boost converter is shown in fig 5. along with the gate signal in Fig 6 followed by the output voltage of the converter.

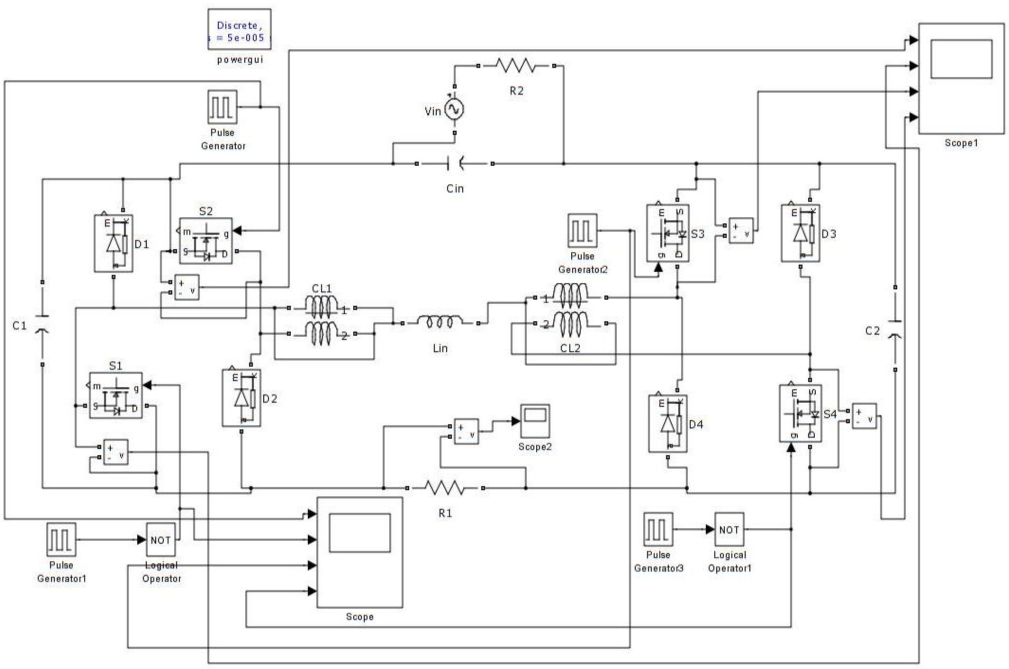

Fig 5. Simulation circuit of the Converter

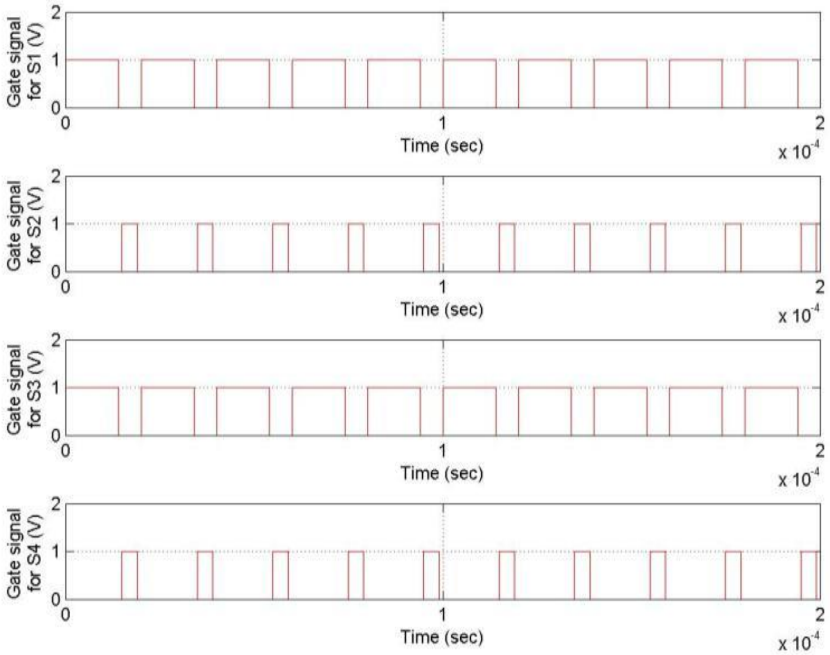

Fig.6 Gate signals during dead – time

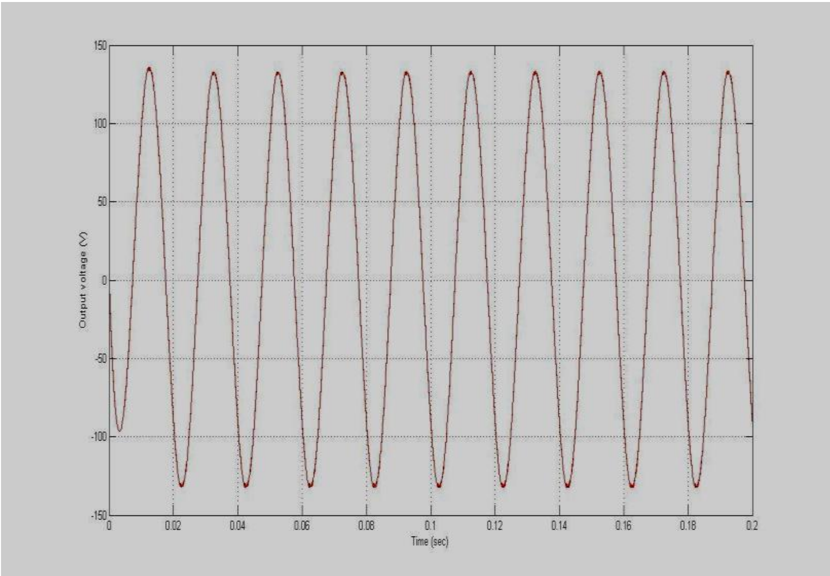

Fig 7. Output Voltage

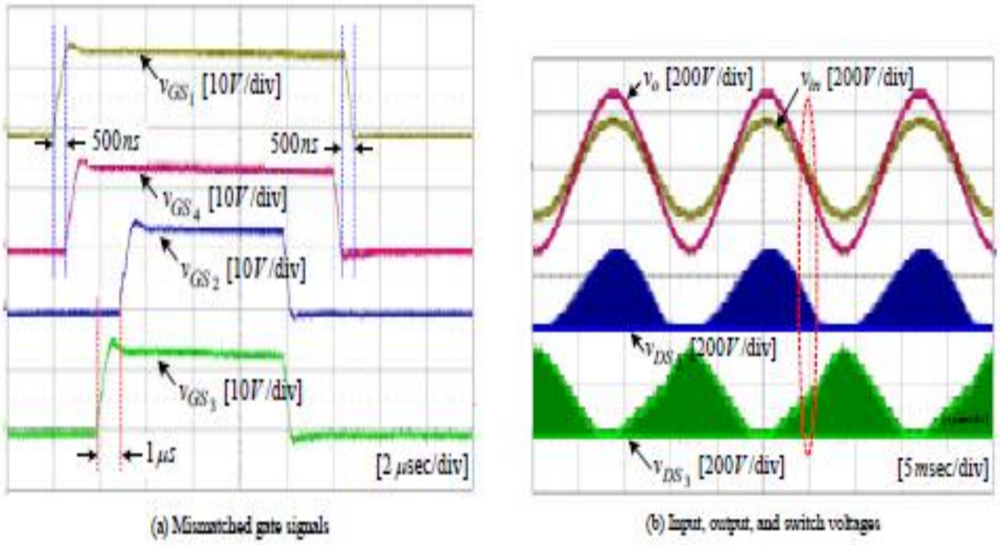

Fig 8. Mismatched gate signals and output voltage

Comparison Table for various Topologies:

Characteristics	**Single - phase Matrix converter**	**A hybrid line commutated converter (LCC) and modular multi-level converters (MMC)**	**Dual Buck Inverter**		**Multilevel converter**	**DC-DC converters**	**AC-AC converters**
			Half - bridge	**Full - bridge**			
Number of Devices	4 bi-directional switches	12 switches (6 for rectifier & 6 for inverter)	2 switches + 2 Diodes	4 switches + 4 Diodes	8 switches + 4 diodes	1 switch + 1 diode	4 switches + 4 Diodes
Shoot-through problem	No	Yes when LCC operated as Inverter	No	No	No	No	Eliminated using soft commutation strategy
Performan	Better	Better	Good	Better	Better	Good	Better
Cost	Medium	Cost efficient	Low	Medium	Medium	Low	Medium
Control technique	SPWM	VDCOL (Voltage dependent current order limiter)	PWM	Hysteresis current control	PWM	PWM	PWM

The converter was able to provide stable output without any additional components or safe commutation schemes. Thus various topologies are compared based on several parameters and are tabulated as follows. The various parameters discussed are the number of devices used, ability to rectify shoot-through problem, performance, cost and control strategy used.

Conclusion

Thus various converter topologies are proposed to reduce the shoot-through problems and eliminate commutation issues. Commutation problems are prevalent in ac converters rather than dc. Thus the future scope is to investigate the commutation issues in inverters by adopting various configurations. Also safe and intelligent commutation strategies are to be employed to predict occurrence of commutation failure and to completely resolve it.

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