Analysis of Multi Level Current Source Inverter for Low Torque Applications

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Abstract

This paper proposes a control strategy for a multi-level Current Source Inverter (CSI) which acts as an interface between renewable energy sources such as wind, solar, fuel cell etc. and grid/loads to satisfy the power demand. The control strategy aims to reduce the number of switches and the number of input sources used in the CSI and obtain an output with least Total Harmonic Distortion (THD) and increased number of levels (13). The proposed system uses seven switches and three current sources to obtain a 13 level output. The new control strategy is tested in different operating conditions in a split phase single phase low torque induction motor. The Simulation model is developed in MATLAB/Simulink. THDs of 13 level outputs from current source inverter is analyzed and compared in detail. A comparative analysis of the proposed CSI with existing CSI topologies is made. It is observed that the proposed topology uses less number of switches and inductors to obtain different levels at the output. The proposed inverter provides better performance with satisfactory results.

Keywords: PWM Techniques, Multi-level inverter, Harmonic Distortion, CSI.

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1 Introduction

Research and development in alternate energy sources for a more economical and environment friendly power generation has gained a lot of traction in the last decade. An optimum solution would be a seamless integration of distributed renewable energy systems such as fuel cells (FC), wind energy conversion system (WECS) and the photovoltaic (PV) system with the grid. Most of the population still prefer grid-connection over the renewable energy systems even though the grid-connected renewable energy system is capable of supporting residential loads and small businesses, primarily due to low investment and reduced maintenance costs. The increase in pollution awareness among the people and stringent government policies over pollution control have now tilted the scale in favor of cleaner renewable energy systems. Rapid advances in renewable energy technologies has enabled people to generate their own power at cheap rates and to contribute to a clean environment. Excess electricity thus generated can also be fed back into the electric grid, and whenever the renewable energy sources are scarce, electricity from the grid can be utilized. There is still the issue of inconsistencies in availability of wind power, solar power and power from fuel cells that lead to power quality issues.

The power quality and the performance of the renewable energy systems are determined on the basis of measurements and the norms followed according to the guide line specified in International Electro-Technical Commission standard, IEC-61400. The influence of the renewable energy systems in the grid system concerning the power quality measurements are the active power, reactive power, variation of voltage, flicker, harmonics, and electrical behavior of switching operation and these are measured according to national/international guidelines.

Design of grid connected converters for solar and wind energy requires detailed modeling of the grid synchronization and modulation techniques including power electronics technology [1] due to technical challenges in connecting a grid and renewable energy sources. This paper proposes a Current Source Inverter (CSI) with less number of switches. This system delivers quality AC single phase output thus solving integration issues. Numerous literature have proposed voltage Source based multi-level Inverter with different control strategies [2–3] to deliver good quality AC. The applications and importance of multi-level inverters are also discussed in the literature [4–6]. It is a challenge in power electronics field to obtain higher number of levels, less harmonics AC output from the light weight inverter with less number of switches. Hence

different control strategies have been adopted by researchers [7–10]. The percentage of Total Harmonic Distortion (%THD) of a multi-level inverter output is a very important factor in measuring its performance. The effect of harmonic distortions and its minimization using different switching strategies are discussed in [11–12]. Various techniques to eliminate the harmonics are proposed in literature [13–14]. Comparative study of %THD of different output voltage levels of multi-level inverters are discussed in [15]. A three phase grid connected current source inverter with multi loop feedback control strategies are discussed [16]. There are many topologies proposed for multi-level output inverters [17–19]. This paper focuses on Multilevel Current Source Inverter (CSI) as it is more advantageous over Voltage Source Inverter (VSI) [3]. In CSI, occurrence of misfiring and commutation problems are considerably lower as compared to voltage source inverters. It handles reactive loads with fewer peaks current. Due to these advantages, the current source inverters are preferred for DC to AC conversion. The proposed CSI delivers a single-phase AC supply with 13 levels and least THD with seven switches by adopting the new control strategy, thereby reducing the size of filter components. This CSI topology removes the need for diodes and uses just one inductor irrespective of the number of levels. The proposed topology is compared with the various existing topologies discussed in [21–23] and it is observed that it uses less number of switches compared to other topologies.

2 Proposed System

The block diagram of the proposed thirteen level current source inverter is shown in Figure 1a.

The aim of this paper is to develop a single phase current source inverter. It uses the DC current sources derived from the renewable energy systems like PV array etc. and an H-bridge inverter connected with the induction motor through a transformer. There are three switches S_1 , S_2 and S_3 connected in series with the DC sources $V_1(40V)$, $V_2(120V)$, $V_3(160V)$ respectively. In

Figure 1a Block Diagram.

order to convert voltage sources into current sources, inductor L is connected in series with it. CSI uses H bridge Inverter with switches H_1 , H_2 , H_3 and H_4 . Different levels of the output voltage is obtained by varying the current flowing through the inductor. The levels of current obtained are 0, I_1 , I_2 , I_3 , I_4 , I_5 and I_6 in a quarter cycle. This paper discusses the voltage level which is proportional to current through the inductor. The objective of this paper is to develop and analyze the new switching technique for a 13 level (7 level per quarter cycle) current source inverter feeding a local load. THD analysis of the 13-level proposed inverter circuit is also carried out and compared with the three, five, seven, nine and eleven level output produced from the same topology using the conventional switching technique. This circuit powers a half HP single phase induction motor for agricultural purpose. The same can be integrated with the local power system for micro-grid applications. Section 3 discusses the seven levels of operation of the proposed current source inverter circuit with the switching logic and Section 4 discusses the simulation results.

3 Circuit Description

The circuit contains three different current sources with switches S_1 , S_2 and S_3 connected in series. By varying the switching pattern, seven different levels of currents are obtained in quarter cycle (5 ms). The proposed circuit in Figure 1b generates the voltage with a peak level of 160V which is further stepped up to 325V peak/230V RMS voltage using 1:2 transformers, which is then is fed to the split phase induction motor load. The transformer also isolates the inverter and the motor load. The transformer's internal inductance also helps in reducing the harmonics in the output waveform. The output of the circuit is measured as a voltage level. The different levels of outputs are 0V, 40V, 80V, 100V, 120V, 140V and 160V, which are proportional to the change in current level of the inductor. The operation of the seven level circuit is explained in the subsections from mode 1 to mode 7. The modes are illustrated in Figures 2 to 6. The pulses are provided to the corresponding switches which has to go to ON state.

3.1 Mode I (Level 1)

In this level, H bridge inverter switches H_1 , H_2 , H_3 and H_4 are turned OFF so that the current delivered to the load is zero. The circuit is totally disconnected from the sources so as to obtain level 1.

Figure 1b Proposed Current Source Inverter.

Figure 2 Mode II operation.

3.2 Mode II (Level 2)

Current source is formed by including the 40V (V_1) source in series with the inductor as shown in Figure 2. Switch gating pulses are provided to S_1 , H_1 and H_2 of the H-bridge inverter, so that a closed path is formed from source V_1 , L_1 , H_1 , Transformer primary, H_2 and source (V_1). This level outputs the current equivalent of V_1 in the output, thus achieving level 2 as 40V.

3.3 Mode III (Level 3)

Figure 3 shows the mode 3 operation of the proposed circuit. Current source is formed by including V_1 , V_2 and the inductor. H-bridge inverter switches remain same as in mode II. Level 3 output is the equivalent of parallel combination of current sources derived from V_1 and V_2 . This results in level 3 output of 80V.

Figure 3 Mode III operation of the circuit.

Figure 4 Mode VI operation of the circuit.

3.4 Mode IV (Level 4)

Value of current source is changed by switching on the voltage sources V_1 and V_3 connected in series with the inductor by switching on S_2 and S_3 as shown in Figure 4. In the H-bridge inverter the pulses are provided to H_1 and H_2 . This provides level 4 output voltage of 100V.

3.5 Mode V (Level 5)

Figure 5 shows the mode 5 operation of the proposed circuit. Current source is formed by including the source V_2 in series with the inductor. Switching pulses for H-bridge inverter being the same as in mode II. This mode outputs V_2 voltage source's current equivalent at the output achieving level 5 (120V).

3.6 Mode VI (Level 6)

The value of current source is changed by switching on the voltage sources V_2 , V_3 connected in series with the inductor by switching on S_2 and S_3 . ON pulses are provided to H_1 and H_2 of the H-bridge inverter. This circuit Figure 6 operation results in level 6 with 140V.

Figure 5 Mode V operation of the circuit.

Figure 6 Mode VI operation of the circuit.

3.7 Mode VII (Level 7)

Figure 7 shows mode 7 operation of the proposed circuit. Current source is formed by including source V_3 in series with the inductor. In this mode, Switches H_1 and H_2 of the H-bridge inverter are still in ON state and outputs 160V as level 7.

Figure 7 Mode VII operation of the circuit.

3.8 Switching Logic

The Switching pattern of the sources and the inverter switches, and level of output is mentioned in Table 1. Switches S_1 , S_2 and S_3 represent the source switches and H_1 , H_2 , H_3 and H_4 represent the inverter switches. The switching table is shown only for one half cycle (Positive cycle); hence H_3 and H_4 are in OFF state. For the negative half cycle H_1 and H_2 would be in OFF state. The different levels obtained are with the switching patterns of source switches S_1 , S_2 and S_3 . The Switching pattern for obtaining the output voltage from three level to 13 level for half a cycle from the same circuit is also shown in Table 1.

Table 1 Switching table

Number of levels	Level	S_1	S_2	S_3	H_1	H_2	H_3	H_4
Three level	0	0	0	0	0	0	0	0
	160	0	1	0	1	0	1	0
Five level	0	0	0	0	0	0	0	0
	100	1	1	0	1	0	1	0
	160	0	1	0	1	0	1	0
Seven level	0	0	0	0	0	0	0	0
	40	1	0	0	1	0	1	0
	100	1	1	0	1	0	1	0
	160	0	1	0	1	0	1	0
Nine Level	0	0	0	0	0	0	0	0
	40	1	0	0	1	0	1	0
	80	1	1	0	1	0	1	0
	120	0	1	0	1	0	1	0
	160	0	0	1	1	0	1	0
Eleven level	0	0	0	0	0	0	0	0
	40	1	0	0	1	0	1	0
	80	1	1	0	1	0	1	0
	100	1	0	1	1	0	1	0
	120	0	1	0	1	0	1	0
	160	0	0	1	1	0	1	0
Thirteen level	0	0	0	0	0	0	0	0
	40	1	0	0	1	0	1	0
	80	1	1	0	1	0	1	0
	100	1	0	1	1	0	1	0
	120	0	1	0	1	0	1	0
	140	0	1	1	1	0	1	0
	160	0	0	1	1	0	1	0

4 Simulation Results and Analysis

Simulation of the proposed circuit for 3 to 13 levels are carried out using conventional switching logic and the switching table for the same and its corresponding THD's are discussed in this section.

4.1 Three Level

V_3 source is brought into the circuit by firing the switch. Using proper switching, the levels $0V$, V_3 (160V) and $-V_3$ ($-160V$) are achieved at the primary side of the circuit. The THD obtained is 48.74% and the peak fundamental voltage magnitude is 281.9V as shown in Figure 8.

Figure 8 Three level output.

Figure 9 Five level output.

4.2 Five Level

The Two voltage sources V_1 and V_3 (40V, 160V) are brought into the circuit by firing the switches S_1 and S_3 . By switching the devices as shown in Table 1, the levels 0V, 100V, 160V, $-100V$, $-160V$ are achieved at the primary side of transformer with the turns ratio 1:2. The waveform and THD of this level are shown in the Figure 9. The obtained THD is 37.09%.

4.3 Seven Level

The two voltage sources V_1 , V_3 (40V, 160V) are brought into the circuit by firing the switches S_1 , S_3 . Using proper switching the levels 0V, 40V, 100V, 160V, $-40V$, $-100V$, $-160V$ are achieved at the primary side of the 1:2 transformer. The waveform and THD of this level are shown in the Figure 10. The obtained THD is 26.07%.

Figure 10 Seven level output.

4.4 Nine Level

All the three voltage sources V_1 , V_2 , V_3 (40V, 120V, 160V) are brought into the circuit by firing the switches S_1 , S_2 , S_3 . With proper switching, the levels 0V, 40V, 80V, 120V, 160V, -40V, -80V, -120V, -160V are achieved at the primary side of 1:2 transformer. The waveform and THD of this level are shown in the Figure 11. The obtained THD is 21.23%.

4.5 Eleven Level

All the three voltage sources V_1 , V_2 , V_3 (40V, 120V, 160V) are brought into the circuit by firing switches S_1 , S_2 and S_3 . Through proper switching, the

Figure 11 Nine level output.

levels 0V, 40V, 80V, 100V, 120V, 160V, −40V, −80V, −100V, −120V, −160V are achieved at the primary side of the 1:2 transformer. The waveform and THD of this are shown in the Figure 12. The obtained THD is 11.03%.

4.6 Thirteen Level

All the three voltage sources V_1 , V_2 , V_3 (40V, 120V, 160V) are brought into the circuit by firing switches S_1 , S_2 and S_3 . With proper switching, the levels 0V, 40V, 80V, 100V, 120V, 140V, 160V, −40V, −80V, −100V, −120V, −140V, −160V are achieved at the primary side of 1:2 transformer. The waveform and THD of this level are shown in the Figure 13. The obtained THD is 9.28%.

Figure 12 Eleven level output.

Thirteen level current source inverter is used to run a single phase induction motor for agricultural purpose (or it could be connected to a grid). The thirteen level output waveform at the primary side and secondary side are shown in Figures 14 and 15 respectively.

4.7 Analysis

Comparison of three to thirteen level output with respect to THD is described in Table 2. It is observed from the waveforms shown through Figures 8 to 13 that 13 level output has very less THD% which suits for running an induction

Figure 13 Thirteen level output with %THD.

motor and also for micro applications using renewable energy sources. As the level increases the THD reduces to less than 5% as per IEEE standards. To support this analysis, the same simulation for twenty one level was carried out and the results for the same is shown in Figure 16. THD lesser than the 3.74% can be obtained when the level is increased more than 21. Thus it is observed that as the level increases the THD decreases.

Figure 14 Thirteen Level output at the primary of transformer.

Figure 15 Thirteen Level output at the secondary of transformer.

Table 2 THD comparison

Output Levels	THD% without the transformer	THD% with the transformer
Twenty One	3.93	3.74
Thirteen	9.29	9.28
Eleven	13.04	11.03
Nine	21.52	21.23
Seven	28.01	26.07
Five	36.48	37.09
Three	48.12	48.74

Figure 16 21 Level output.

5 Comparative Analysis of Proposed Topology with Different Topologies

The proposed topology is compared with the different CSI topologies discussed in the literature [20–23]. The topologies such as Current Mode logic [21], inductor cell topology [22], Asymmetric and symmetric CSI topology [23] are compared with the proposed topology. Table 3 shows the generalized equation for calculation of number of switches, sources and inductors for all the topologies.

Table 4 describes the comparison between the different topologies. Number of switches, sources and inductors for different topologies are given. From the comparison charts from Figures 17 to 19, it is clear that the proposed topology utilizes less number of switches and inductors as compared to other topologies for the different number of levels.

Table 3 List of different topologies formulae

Type of Topology [N = Number of Levels for 1 Full Cycle]	No. of Switches	No. of Sources	No. of Inductors
Current Model Logic Topology	$4 [\log_2 (N - 1) - 1] + 4$	1	$2 [\log_2 (N - 1) - 1]$
Inductor Cell Topology	$4 [\log_2 (N - 1) - 1] + 4$	1	$[\log_2 (N - 1) - 1]$
Asymmetrical Modular reduced count Switch CSI	$2 [\log_2 (N + 1) + 1]$	$2 [\log_2 (N + 1) - 1]$	$2 [\log_2 (N + 1) - 1]$
Symmetrical Modular reduced count Switch CSI	N+1	$\frac{N - 1}{2}$	$\frac{N - 1}{2}$
Proposed topology	$[\log_2 (N + 1) - 1]$	$[\log_2 (N + 1) - 1]$	1

Table 4 Comparison of different topologies for different levels

No. of levels for full cycle	Current Mode Logic [21]		Inductor cell [22]		Asymmetrical Modular reduced count Switch				Symmetrical Modular reduced count Switch				Actual-Proposed			
	Switches		Sources		Switches		Sources		Switches		Sources		Switches		Sources	
	Number of	Inductors	Number of	Inductors	Number of	Inductors	Number of	Inductors	Number of	Inductors	Number of	Inductors	Number of	Inductors	Number of	Inductors
3	4	1	0	4	1	0	4	1	2	4	1	2	1	1	1	1
5	8	1	2	8	1	1	8	4	4	6	2	2	2	2	2	1
7	12	1	4	12	1	2	8	4	4	8	3	3	2	2	2	1
9	12	1	4	12	1	2	8	4	4	10	4	4	2	2	2	1
11	12	1	4	12	1	2	10	6	6	12	5	5	3	3	3	1
13	16	1	6	16	1	3	10	6	6	14	6	6	3	3	3	1
15	16	1	6	16	1	3	10	6	6	16	7	7	3	3	3	1
17	16	1	6	16	1	3	10	6	6	18	8	8	4	4	4	1
19	16	1	6	16	1	3	10	6	6	20	9	9	4	4	4	1
21	16	1	8	16	1	4	12	8	8	22	10	10	4	4	4	1
23	20	1	8	20	1	4	12	8	8	24	11	11	4	4	4	1

Figure 17 Comparison of number of switches with different topologies.

Figure 18 Comparison of number of sources with different topologies.

Figure 19 Comparison of number of inductors with different topologies.

6 Conclusion

The proposed Multi level CSI delivers 230V, 50Hz alternating voltage with less harmonic distortions. So, the L and C values that are required to reduce the harmonics of the filter is considerably reduced. The THD of the CSI output is analyzed. The efficient switching pulse generation causes thirteen different levels at the output with minimum of three different current sources. The proposed topology utilizes less number of switches, sources and inductors for obtaining different levels of at output and is confirmed by comparing with the other topologies. This topology is therefore well suited for renewable energy sources and micro grid applications.

References

- [1] Jianyu Bao, Weibing Bao, and Jie Gong (2012). A PWM multilevel current-source inverter used for grid-connected wind energy conversion system. *Energy Procedia*, 6, 461–466.
- [2] Rodriguez, J., Lai, J. S., and Peng, F. Z. (2002). Multilevel inverter: A survey of topologies, controls and application. *IEEE Trans. Industrial Electronics*, 49(4), 724–738.

- [3] Suroso and Toshihiko Noguchi (2012). Multilevel current waveform generation using inductor cells and H-bridge current source inverter. *IEEE Transactions on Power Electronics*, 27(3).
- [4] Bao, J. Y., Bai, Z. H., Wang, Q. S., and Zhang, Z. C. (2006). A new three-phase 5-level current-source inverter. *Journal of Zhejiang University Science A*, 7(12), 1973–1978.
- [5] Rosan Kumar, P., et al. (2012). A five level inverter topology with single DC supply by cascading a flying capacitor and an H-bridge. *IEEE Transactions on Power Electronics*, 27(8).
- [6] Dhal, R. K. and Roy, T. (2015). A comparative study between different multi level inverter topologies for different types of bus clamping PWM techniques using Six Region Selection Algorithm. *Michael Faraday IET International Summit 2015*, Kolkata, pp. 392–398.
- [7] Athira, S. and Deepa, K. (2015). Modified bidirectional converter with current Fed inverter. *International Journal of Power Electronics and Drive Systems (IJPEDS)*, 6(2), 396–410.
- [8] Rashmi, M. R. and Anu, B. (2013). Cascading of diode clamped multi-level inverter boosters for high voltage applications. *Applied Mechanics and Materials*, 313–314, 876–881.
- [9] Nair, R., Mahalakshmi, R., and Sindhu Thampatty, K. C. (2015). Performance of three phase 11-level inverter with reduced number of switches using different PWM techniques. *2015 International Conference on Technological Advancements in Power and Energy (TAP Energy)*, Kollam, pp. 375–380.
- [10] Deepa, K., Savitha, P. B., and Vinodhini, B.B. (2011). Harmonic analysis of a modified cascaded multilevel inverter. *2011 1st International Conference on Electrical Energy Systems, ICEES 2011*, Chennai, Tamilnadu, pp. 92–97.
- [11] Kumar, A. N., Tangirala, A., Joji, S., Diwagar, S. V., and Sujith, M. (2017). Comparative analysis of switching strategies for harmonic minimization in MLI. *2017 2nd IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT)*, Bangalore, pp. 861–868.
- [12] Mahalakshmi, R. and Sindhu Thampatty, K. C. (2015). Implementation of grid connected PV array using quadratic DC–DC converter and single phase multi level inverter. *Indian Journal of Science and Technology*, 8(35), 1–5.
- [13] Porselvi, T., Deepa, K., and Muthu, R. (2018). FPGA based selective harmonic elimination technique for multilevel inverter. *International*

- Journal of Power Electronics and Drive System (IJPEDS)*, 9(1), 166–173.
- [14] Porselvi, T., Deepa, K., and Muthu, R. (2018). Hardware implementation of three phase five-level inverter with reduced number of switches for PV based supply. *Journal of Green Engineering*, 7(4), 527–546.
 - [15] Azmi, S. A., Tajuddin, M. F. N., Mohamed, M. F., and Hwai, L. J. (2017). Multi-loop control strategies of three-phase two-level current source inverter for grid interfacing photovoltaic system. *2017 IEEE Conference on Energy Conversion (CENCON)*.
 - [16] Durgasukumar, G. and Pathak, M. K. (2011). THD reduction in performance of multi-level inverter fed induction motor drive. *India International Conference on Power Electronics 2010 (IICPE2010)*, New Delhi, pp. 1–6.
 - [17] Porselvi, T. and Muthu, R. (2011). Comparison of cascaded H-bridge, neutral point clamped and flying capacitor multilevel inverters using multicarrier. *PWM' Proceedings of Annual IEEE India Conference (INDICON 2011)*, pp. 1–4.
 - [18] Porselvi, T. and Muthu, R. (2012). Seven level three phase Cascaded H-Bridge inverter with single DC source. *ARPJ Journal of Engineering and Applied Sciences* 7(12), 1546–1554.
 - [19] Porselvi, T. and Preethi, D. (2016). Comparison between Five-Level and seven level Active Neutral point clamped converter for photovoltaic energy generation. *2016 International Conference on Computation of Power, Energy Information and Communication (ICCPEIC)*, pp. 600–606.
 - [20] Barbosa, P. G., Braga, H. A. C., and Teixeira, E. C. (2006). Boost current multilevel inverter and its application on single-phase grid-connected photovoltaic systems. *IEEE Trans. Power Electron.*, 21(4), pp. 1116–1124.
 - [21] Vázquez, N., García, L.D.C., Hernández, C., et al. (2013). A grid-connected multilevel current source inverter and its protection for grid-disconnection. *Int. J. Photoenergy*.
 - [22] Suroso and Noguchi, T. (2012). Multilevel current waveform generation using inductor cells and H-Bridge current-source inverter. *IEEE Trans. Power Electron.*, 27(3), 1090–1098.
 - [23] Ebrahim Seifi Najmi and Ali Ajami (2015). Modular symmetric and asymmetric reduced count switch multilevel current source inverter. *IET Power Electronics*, 1–11.

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