Modelling and Simulation of Single Phase Fifteen-level Inverter with Reversing Voltage

I .William Christopher, R .Ramesh, P.Sathiyabama, R.Pavithra, G.Ramyaselvi, P. Saranya

Abstract—This paper presents modeling and simulation of a single phase Fifteen-Level Inverter (FLI) with reversing voltage. Multilevel inverter offers high power capability. Its performance is highly superior to that of conventional two-level inverter due to reduced harmonic distortion, lower electromagnetic interference and higher dc link voltage. The inverter is capable of producing fifteen levels of output voltages (Vdc, 6Vdc/7, 5Vdc/7, 4Vdc/7, 3vdc/7, 2Vdc/7, Vdc/7, 0, -Vdc/7, -2Vdc/7, -3Vdc/7, -4Vdc/7, -5Vdc/7,-6Vdc/7,-Vdc) from the DC supply voltage. Theoretical predictions are validated using MATLAB Simulink tool box.

Index Terms—Fifteen Level Inverter (FLI), Reversing voltage (RV).

1 INTRODUCTION

TWO decays ago multilevel power conversion was first introduced. In general multilevel inverter can be viewed as voltage synthesizers, in which the high output voltage is synthesized from many discrete smaller voltage levels. The values of all voltage sources are equal so this topology is a symmetrical topology [9]. By duplicating the middle stage, this topology easily extends to higher voltage levels. It can also be applied for three – phase applications with the same principle.[1] The main disadvantage associated with the multilevel configurations is their circuit complexity, requiring a high number of power switches that must be commutated in a precisely determined sequence by a dedicated (and complex) control circuit; they also require a great number of auxiliary dc levels, provided either by independent supplies or, more commonly, by a cumber some array of capacitive voltage dividers. In this case, ensuring that the dc voltages are kept in equilibrium is another factor that increases the complexity of the control circuit [2-8].This paper presents an overview of new multilevel inverter with reversing voltage. This topology needs less number of components when compared to conventional topologies. There is no need for all the switches to work in high frequency which leads to simpler and more reliable control of inverter. This topology separate output voltages into two parts. One part is level generation and other part is polarity generation [1].

This paper is organized as follows. First, the power circuit configuration and its advantage presented in section 2. Then the power circuit operation includes the modes of operation discussed in section 3. Simulation result of the fifteen level inverter circuit is given in section 4.

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2 POWER CIRCUT

2.1 Power Circuit Description

The proposed single phase fifteen level inverter was developed from the seven level inverter .It consist of single phase conventional H-Bridge inverter, eighteen bidirectional switches and DC sources[1].The RV topology in Single phase Fifteen Level Inverter is shown in figure 1. As can be seen, it requires eighteen switches and seven sources.

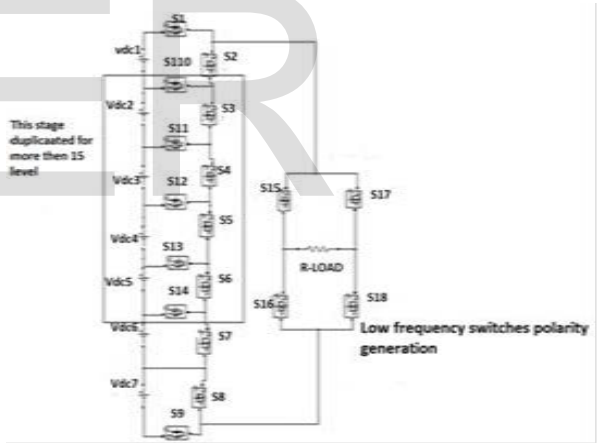

Fig.1 Schematic diagram of Fifteen Level Inverter

2.2 Power Circuit Advantages

This topology requires less components compared to conventional inverter. Some applications for these new converter include industrial drives, Flexible AC transmission system and vehicle propulsion. This topology is redundant and flexible in the switching sequence. Lower electromagnetic interference and total harmonic distortion.

3 POWER CIRCUIT OPERATION

The inverter is capable of producing fifteen levels of output voltages (Vdc,6Vdc/7,5Vdc/7, 4Vdc/7, 3vdc/7, 2Vdc/7, Vdc/7,0, -Vdc/7, -2Vdc/7, -3Vdc/7, -4Vdc/7, -5Vdc/7,-6Vdc/7,-Vdc) from the DC supply voltage shown in figure.2.

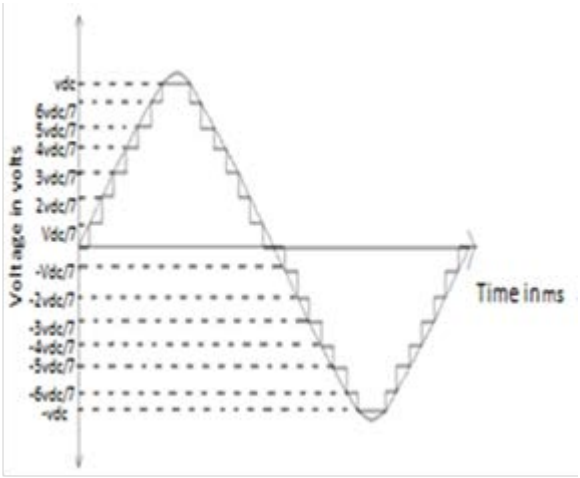

Fig .2 Output waveform of Fifteen Level Inverter

There are fifteen modes of operation in which switch 9 is ON for all the modes except eighth mode.The different voltage levels of the inverter can be synthesized from the following modes of operation and can be understood using table 1

TABLE 1
SWITCHING COMBNIATIONS REQUIRED TO GENERATE THE FIFTEEN – LEVEL OUTPUT VOLTAGE

Voltage Levels	Switches To Be Turned On	
	MODE 1	MODE 2
Level 0	S2-S8,S15,S18	S1,S3-S8,S10,S15,S18
Level 1	S2-S7,S9,S15,S18	S1,S4-S8,S11,S15,S18
Level 2	S2-S6,S9,S14,S15,S18	S1,S4-S8,S11,S15,S18
Level 3	S2-S5,S9,S13,S15,S18	S1,S5-S8,S12,S15,S18
Level 4	S2-S4,S9,S12,S15,S18	S1,S6-S8,S13,S15,S18
Level 5	S2-S3,S9,S11,S15,S18	S1,S7,S8,S14,S15,S18
Level 6	S2,S9,S10,S15,S18	S1,S8,S15,S18
Level 7	S1,S9,S15,S18	-

A. .Level 0 Operation
In the level 0 operation switches S2-S8,S15and S18 are turned ON . This provides an output voltage level of 0volts.

B .Level 1 Operation:
The level 1 has two modes of operation. In the first mode switches S2-S7,S9,S15 and S18 are turned on and in second mode of operation S1,S3-S8,S10,S15,and S18 are turned on. This provides an output voltage level of Vdc/7 volts.

C .Level 2 Operation:
The level 2 has two modes of operation. In the first mode switches S2-S6,S9,S14,S15 and S18 are turned on and in second mode of operation S1,S4-S8,S12,S15,and S18 are turned on. This provides an output voltage level of 2 Vdc/7 volts.

D. Level 3 Operation:
The level 3has two modes of operation. In the first mode switches S2-S5,S9,S13,S15 and S18 are turned on and in second mode of operation S1,S5-S8,S12,S15,and S18 are turned on. This provides an output voltage level of 3Vdc/7 volts.

E .Level 4 Operation:
The level 4 has two modes of operation. In the first mode switches S2-S4,S9,S12 S15 and S18 are turned on and in second mode of operation S1,S6-S8,S13,S15,and S18 are turned on .This provides an output voltage level of 4Vdc/7 volts.

F .Level 5 Operation:
The level 5 has two modes of operation. In the first mode switches S2,S3 ,S9,S11,S15 and S18 are turned on and in second mode of operation S1,S7,S8,S14,S15,and S18 are turned on. This provides an output voltage of 5Vdc/7 volts.

G .Level 6 Operation:
The level 6 has two modes of operation. In the first mode switches S2-S9,S10,S15 and S18 are turned on and in second mode of operation S1,S8,S15,and S18 are turned on. This provides an output voltage level of 6Vdc/7 volts..

H. Level 7 Operation:

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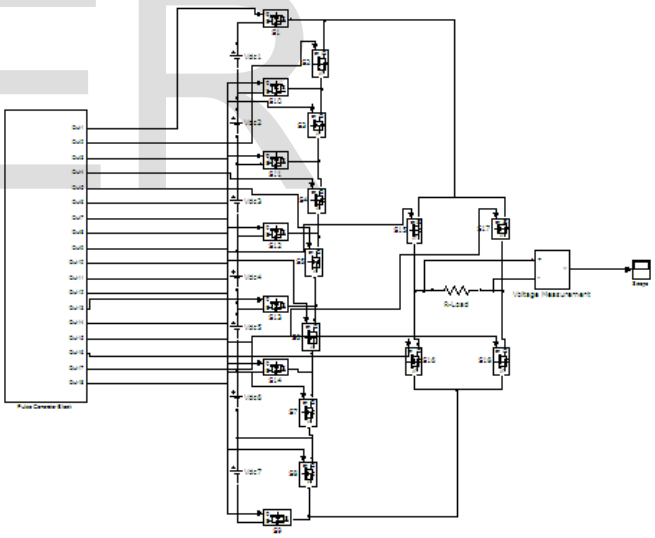

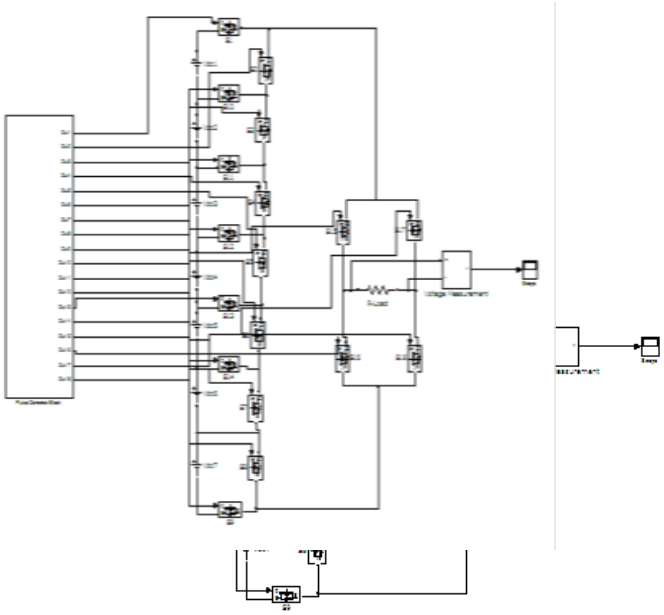

Fig .3 Single phase FLI Simulation Circuit

The fig 4 shows the switching sequence for switches S1-S9 and the fig 5 shows the switching sequence for switches S10-S18

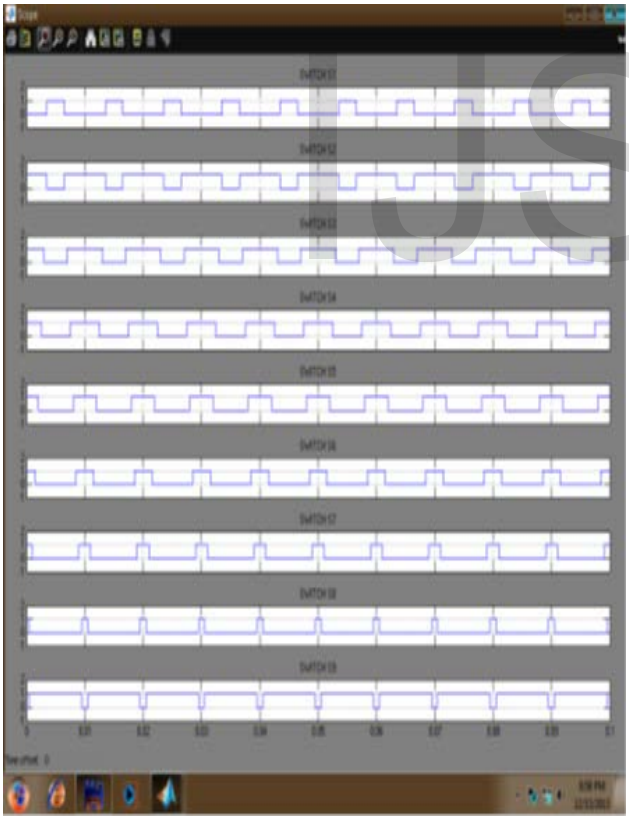

Fig .4 Switching sequences for switches S1-S9

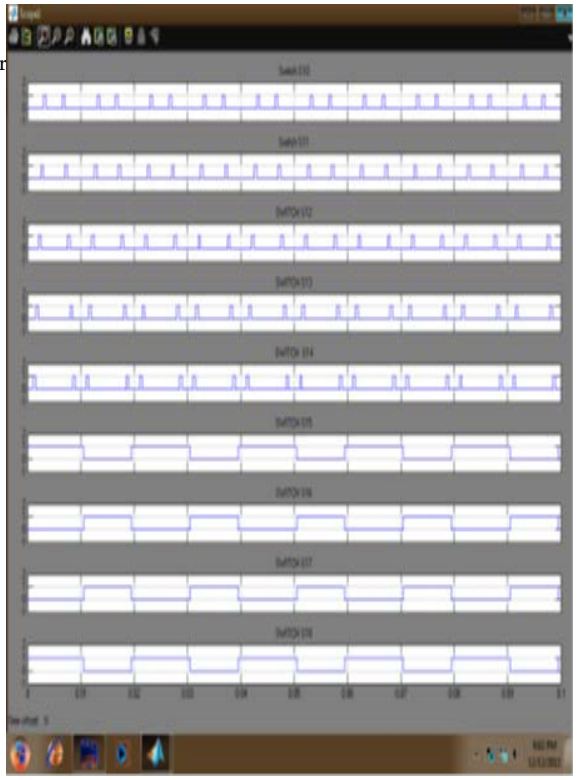

Fig .5 Switching sequences for switches S10 -S18

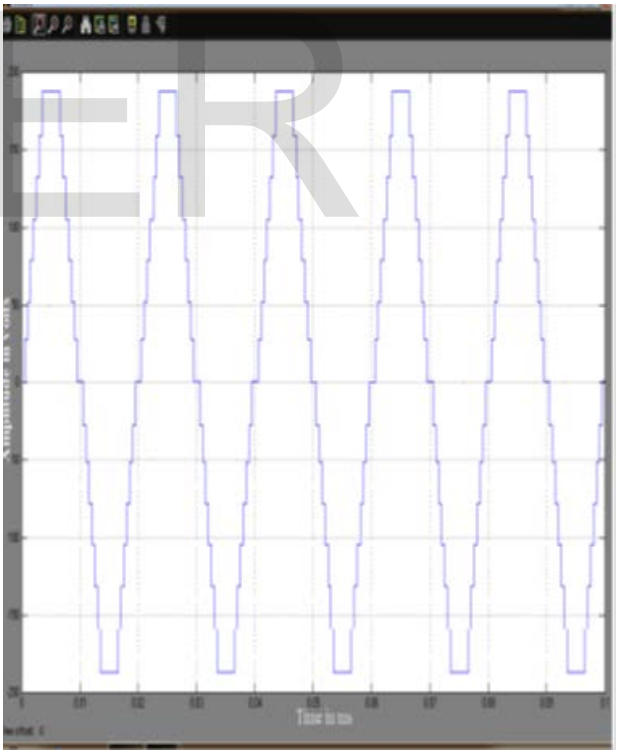

Fig .6 Simulated fifteen level output waveform

The fig 6 shows Simulation of fifteen level inverter output waveform.It is clearly visible that the simulated output waveform is very close to the ideal output defined for a Single Phase fifteen-level inverter circuit. It is

clearly visible that the simulated output waveform is very close to the ideal output defined for a Single phase Fifteen Level - Inverter (FLI) circuit. The Fifteen levels of voltages are Vdc=182V, 6Vdc/7=156V,5Vdc/7=130V,4Vdc/7=104V,3vdc/7=78V, 2Vdc/7=52V, Vdc/7=26V,0V, -Vdc/7=-26V, -2Vdc/7=-52V, -3Vdc/7=-78V, -4Vdc/7=-104V, -5Vdc/7=-130V,-6Vdc/7=-156V,-Vdc = -182V.

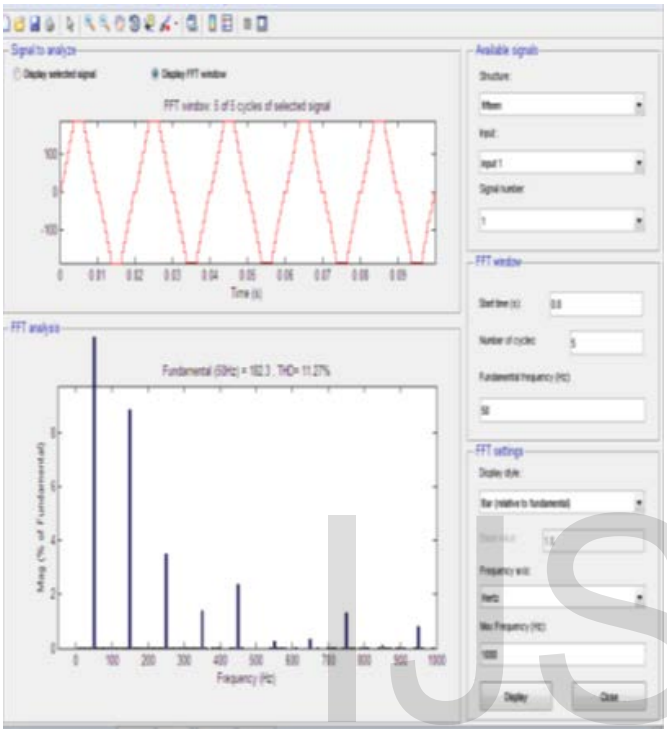

Fig .7 Total Harmonic Distortion for SFLI

The Total Harmonic Distortion (THD) of the fifteen level inverter is observed that 11.27% and fundamental voltage is 182.3V(50Hz) that has been illustrated in Fig. 7.

5 CONCLUSION

This paper presented a simulation model of a single-phase fifteen-level inverter with reversing voltage using MATLAB Simulink tool box. The inverter model developed was shown to provide accurate results and provided valuable insight into fifteen level inverter performances. A further development of the fifteen- level inverter, able to be applied to any number of voltage levels within the power switches maximum voltage, is now under consideration.

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