SINGLE PHASE MULTILEVEL INVERTER BASED ON A NOVEL SWITCHING SCHEME USING SEPIC CONVERTER FOR BATTERY POWERED APPLICATION

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***Abstract*—This paper introduces a single phase multilevel inverter (MLI) occupying a novel switching scheme. Multilevel inverter gives high power capability, affiliated with lower output harmonics. Their main disadvantage is their complication, involving a great number of power devices and passive component, and a comparatively complex control circuitry. This new idea proposes an indicative reduction in the number of power devices and capacitor suitable to implement multilevel output with a battery powered application. In the proposed scheme, different voltage levels are achieved by changing duty cycle value of the DC-DC SEPIC (Single Ended Primary Inductance converter) converter. So, only five controlled switches are required to implement the multilevel inverter and no additional components are required. The proposed scheme has been designed and simulated in the MATLAB/SIMULINK environment and the results have been validated.**

***Index Terms*—multilevel inverter; SEPIC; Duty cycle; Battery powered application.**

I. INTRODUCTION

Multilevel inverter possesses become popular in just out years by reason of the advantages of high power quality waveforms, less harmonic distortion, little common mode voltage, low switching operations, medium high-voltage and high power capability. Typically inverter is a device so that converts DC electrical power to AC form using some electronic circuits. Usually, simple inverter gives 2 or 3 level output voltage. But multilevel inverter delivers 3 or more output voltage levels. It outcomes a stepped output voltage with shortened harmonic distortion when compared to a 2 level inverter. It furnishes higher output voltage levels. The inverter needs DC stable voltage which can be seized from the converter.

The switching mode DC/DC power conversion system can be accomplished by different circuit topologies. In dispersion, the buck, boost, buck-boost and CUK converter are the basic and predominantly used.

One by one of the circuit has its advantages and disadvantages and the choice builds upon a specification for power changeover system. The output voltage of the SEPIC is contained by the duty cycle of the control transistor MM1.The output voltage can be greater than, less than, or equal to the input voltage. The buck-boost converter can also step up and step down the output voltage, but the output is inverted.

The SEPIC converter can keep the same polarity and the same ground reference as long as the input and output. Likewise, it's a small input current ripple and simply to enhance the multiple outputs. The battery voltage can be above or below the regulator output voltage. Where SEPIC's are favorable in the appliance. It has turned into beloved in modern years in the battery-powered system that must step up or down voltage build upon the charge flat of the battery.

Multilevel inverter (MLI) crucial disadvantage is their ramification, demanding an enormous count of power devices and passive components, and an averagely complicated control circuitry. This new idea has taken the demerits of MLI to indicative degradation in the number of switching devices. Only five controlled switches are needed to the multilevel outputs. One controlled switch has the higher switching frequency of the converter side and remaining four are inverter side that has a lower switching frequency. This can use to pattern the multilevel output by altering of duty cycles in MATLAB package.

II. THE CONCEPT OF MULTILEVEL INVERTERS

Conventional two-level inverters generally produce an output AC voltage against an input DC voltage. Pulse width modulation switching scheme is recycled to make the AC output voltage. In the view of Multilevel inverter topology (MLI), several DC voltage levels are added together to generate a continuous output waveform (as shown in figure 3). The gained output waveform has lower dv/dt and harmonic distortions.

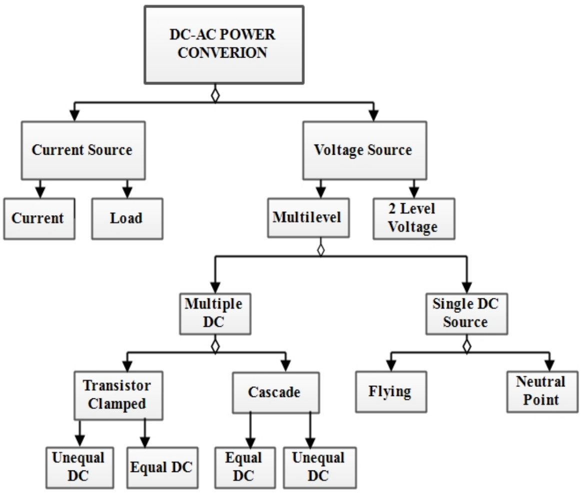

Fig .1 DC-AC power conversion

The circuit design is more complex with the boost in voltage levels. It wishes a sophisticated switching controller circuit also. As in figure 1, DC-AC power conversion comprises of two types. They are a current source and voltage source. In this multilevel inverter comes from the voltage source.

The input side DC voltage sources are gathered against batteries, capacitor, renewable energy system, etc.

Hence the interesting appearance can shorten as follows

1. Shortened harmonic distortion
2. Higher number of voltage level
3. Staircase waveform quality
4. Operates at both high switching frequency pulse width modulation and fundamental
5. Decreased switching losses.
6. Superior electromagnetic compatibility
7. Increment power quality.

Table 1: The comparison between a 2-level and a 3-level inverter

SI.No	Conventional Inverter	Multilevel inverter (MLI)
1	THD is large in the output waveform	THD is small in the output waveform
2	Great switching stresses	Humble switching stresses
3	Not used for high voltage appliance	Used for high voltage appliance
4	Production of voltage levels cannot be high	Production of voltage levels can be high
5	High EMI and dv/dt	Low EMI and dv/dt

III. PRINCIPLE OF PROCEDURE AND STEADY STATE REASONING

SEPIC (Single-ended primary inductance converter) is shown in Fig.2. The representation of peripherals in this converter is identical to the vital SEPIC converter. Build upon whether or not the inductor current L1 falls to zero, the converter will accomplish in either continuous or discontinuous conduction modes. In mentioning thesis, only continuous conduction mode (CCM) is examined.

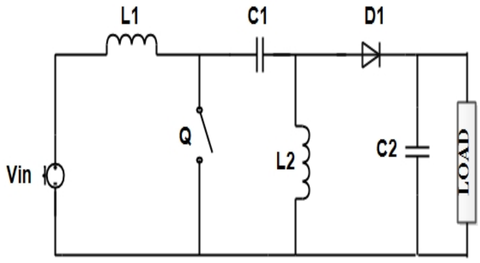

Fig. 2. SEPIC converter

There are two modes in one switching cycle that are shown in Fig.2a and Fig.2b.In mode 1, During switch Q switches on, currentIL1 elaborates in the negative direction. (Methodically, its decline due to arrow direction), The energy to increase the current IL1 comes from the input supply source. In view of S1 is closed, and the instantaneous voltage VC1 is closely Vin, the voltage VL2 is near –Vin. Hence, the capacitor C1 provides the energy to raise the magnitude of the current in IL2 and in-kind increase the energy stored in L2. While the switch is closed, the diode is turned off, and the circuit is as shown in Fig.2a.The voltage over L1 for the interval DT is, VL1=Vs. Following equations can be derived using Fig.2a.

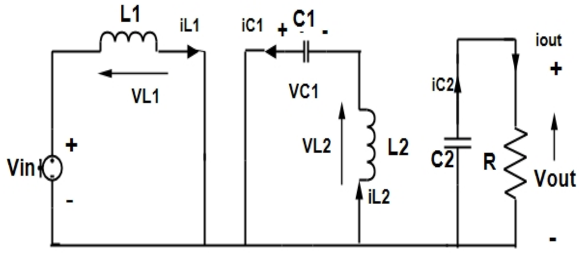

Fig. 2a. SEPIC turn on mode

When the switch Q is switched off, the current IC1 converts the equal as the current IL1, as inductors do not own instantaneous difference in current. The current IL2 will extend in the negative direction, in truth, it never reverses direction.

It can notice against the diagram that a negative IL2 will include the current IL1 to increase the current forwarded to the load. This energy inward the capacitors. However, as the inductor current not ever falls to zero, it continues to source the circuit.

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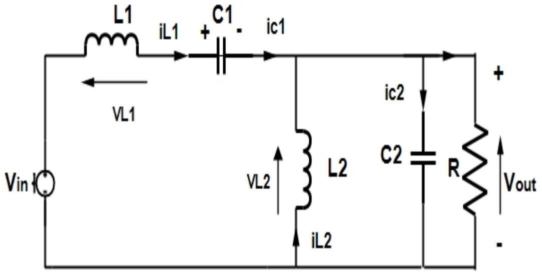

Fig. 2b. SEPIC turn off mode

A. Mathematic Analysis

When the switch is on, and the circuit is as shown in Fig. 4.3 the diode is on, Kirchhoff 's voltage law over the outlying passage gives,

$$VL1 = -Vo \quad (1)$$

In periodic operation, the average voltage across an inductor is zero.

$$(VL1, Q\ closed)\ (DT) + (VL1, Q\ open)\ (1-D)\ T=0$$

$$Vs\ (DT) - Vo\ (1-D)\ T=0$$

$$Vo=Vs\left(\frac{D}{1-D}\right) \quad (2)$$

Where D is the duty cycle that can be declared as,

$$D = \frac{Vo}{Vo+Vs} \quad (3)$$

This result is identical to that of the buck-boost and CUK converter equations, with the important difference that there is no polarity reversal among input and output voltages.

(i) Inductor selection:

The deviation in IL1 during the switch is closed is from,

$$VL1=Vs=L1\left(\frac{\Delta IL1}{DT}\right)$$

Fixing for ΔIL1,

$$\Delta IL1 = \frac{Vs\ D}{L1\ f} \quad (4)$$

(ii) Capacitor selection:

In the act of a thumb rule, the capacitor C1 is seized just as 10μF.The output step subsisting of the diode, C2, and the load resistor is the equal as in the boost converter also, so the output ripple voltage is taken as

$$\Delta Vo=\Delta VC2=\frac{Vo\times D}{R\times C2\times f} \quad (5)$$

Solving for C2,

$$C2 = \frac{Vo\times D}{R\times \Delta VC2\times f} \quad (6)$$

B. Simulation Results

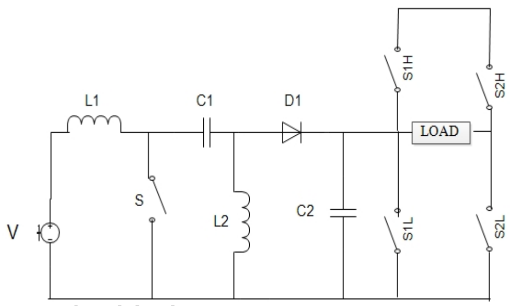

Fig. 3. SEPIC with multilevel inverter

A new multilevel inverter, whose electrical circuit is shown in Fig. 3, is presented in this work. It has some advantages when compared with the previously referenced current-source Boost CML inverter (Fig.4), which employs six self-commutated switches. Moreover, only one balance inductor is necessary. The proposed here needs only five self-commutated switches.

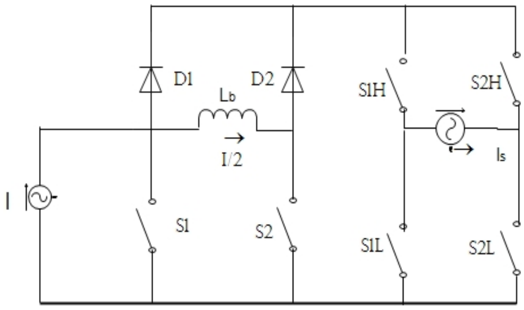

Fig. 4. Boost CML inverter

Since Thyristor (spontaneous blocking) could be used to implement the switches and up to five-level can be synthesized in the output voltage waveform with this switching scheme. Only five controlled switches are needed for the appliance the multilevel outputs.

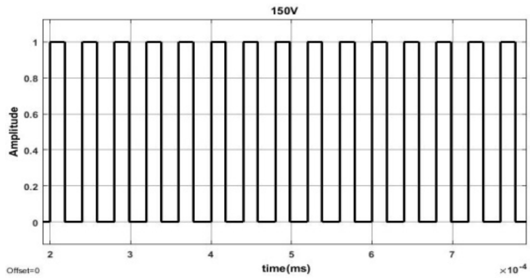

Fig. 5. Pulse waveform for 150V

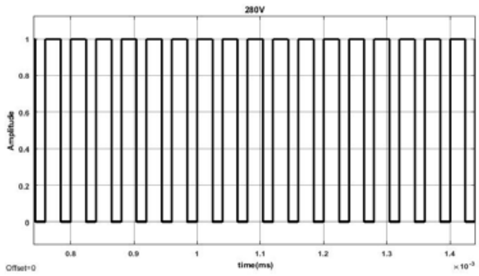

Fig. 6. Pulse waveform for 280V

DC-DC SEPIC converter pulse waveform has been Plotted using 150v and 280v voltage values is shown in figure 5 and 6. One controlled switch has the higher switching frequency of the converter side and remaining four are inverter side that has a lower switching frequency. This can use to pattern the multilevel output by altering of duty cycles in MATLAB package. The prospective system presented a good performance regarding efficiency

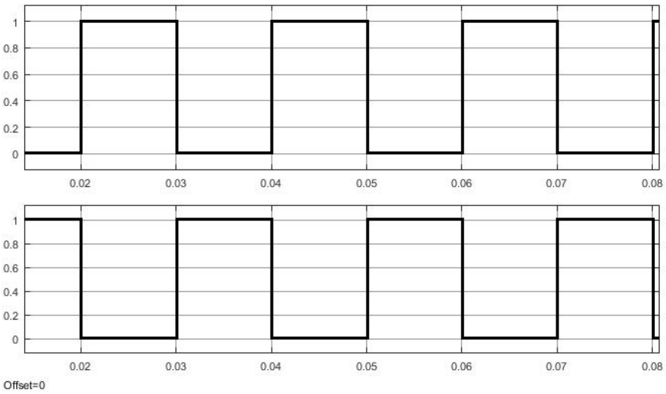

Fig. 7. Gate pulses for S1H,S2L and S2H,S1L

Inverter (DC-AC) side pulse values depend upon the pulse given in the pulse generator values that is shown in Fig 7 has its amplitude as 1. which provides 150v output voltage with the input 180v. On the other hand 280v output levels obtained with the help changing Duty cycle in inverter side. fig 7 has S1H and S2L on (closed switch). when S2H and S1L will be open circuit. Likewise, S2H and S1L on when S1H and S2L can be switched off.

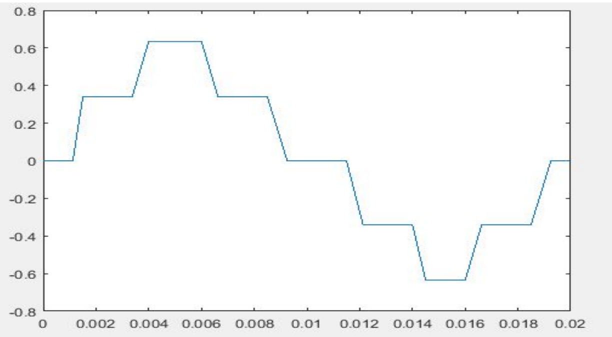

Fig. 8. Five-level current output waveform

SEPIC converter involving multilevel inverter circuit is proposed. Fig.8 shows a five-level output waveform for current. The single-ended primary inductance converter (SEPIC) is a progressively popular topology, particularly in the battery-powered application. Simulation result demonstrates that the proposed multilevel output based on a multilevel inverter and there is no out of Auxiliary switches.

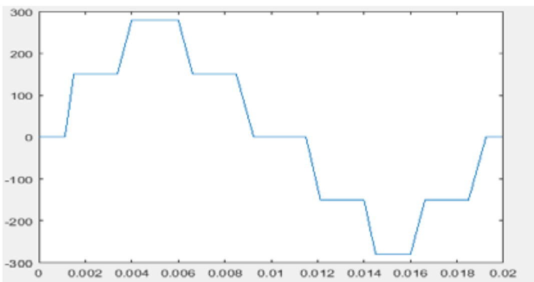

Fig. 9. Five-level voltage output waveform

In this effort, SEPIC converter adopting multilevel inverter circuit is proposed. Fig.9 shows a five-level output waveform for voltage waveform. The inverter adopts a full-bridge configuration without an auxiliary circuit. The new idea of proposed five-level inverter has been created with the help of changing of duty cycle.

IV. CONCLUSION

This paper granted the switching scheme as multilevel output from the battery-powered application, which was made by means of a novel switching scheme form on single-phase inverter. Part of mathematical expressions for this SEPIC converter has been conferred in order to produce form guidance for the circuit components. Experimental waveforms and measured parameters, retrieved from the SEPIC converter with single-phase inverter, have been used to justify the proposed theoretical concepts. Through simulation, it is seen that proposed inverter provokes high-quality voltage waveforms, reducing harmonic levels beyond rising output voltage levels. The output voltage of the inverter left out filter is a virtually sinusoidal waveform. More booming the number of levels will enlarge the configuration of the output waveform to be more sinusoidal. Experimental waveforms and measured parameters, obtained from the SEPIC converter with single-phase inverter, have been used to justify the proposed theoretical concepts.

Reference

[1] pedro gomes barbosa and Henrique Antonio carvalho braga 'Boost current multileveliverter and its application on single-phase Grid connected photovoltaic system, "IEEE transactions on power electronics, vol. 21, no. 4 july 2006

[2] A.Nabae and H. Akagi, "A new neutral-point clamped PM inverter," IEEE Trans. In. Appl, vol. IA-17, no. 5, pp. 518-523, sep./oct. 1981.

[3] A.Ajami, H Ardi and H.Farakhor, "A novel high step-up DC/DC converter based on integrating coupled inductor and switched capacitor technique for renewable energy applications," IEEE Trans. Power Electron, vol.30,no 8,pp.4255-4263, Aug.2015.

[4] B-R Lin and C-H Huang, "Implementation of a three-phase capacitor clamped active power filter under an unbalanced condition," IEEE Trans. Ind. Electron., vol. 53, no. 5,pp. 1621-1630, oct 2006.

[5] B.Kroposki and R. de Blasio, "Technologies for the new millennium photovoltaics as a distributed resource," 1798-1801, in Proc. IEEE power Eng. Soc. Summer Meeting, 2000, pp.

[6] anjali Krishna r and dr.l padma suresh "A brief review on multilevel inverter topologies," international conference on circuit, power and computing technologies (iccpct), 2016

[7] C.Hochgraf, R. Lasseter, D. Divan, andT.A. Lipo, "comparison of multilevel inverters for static var compensation" pp. 921-928, in conference. IEEEIAS Annu. Meeting, oct. 1994

[8] D.-W. Kang, B-K Lee. J-H. Jeon. T-J, Kim, and D-S. Hyun, "A symmetric carrier technique of CRPWM for voltage balance method of flying capacitor multilevel inverter," IEEE Trans. Ind. Electron., vol. 52,no. 3, pp.879-888, Jun.2005

[9] Yam p. siwakoti and mohsen soltani "A novel quasi-sepic high-voltage boost dc-dc converter," IEEE transactions on power electronic, 2017

[10] E. Schempp and C. Russ, "Application of high temperature super conducting. coils as inductor in switching power supplies," IEEE Trans. Appl. Supurcond., vol. 3, no. 1, pp.563-565,Mar. 1993.

ISSN 2229-5518
[11] E.C. Teixeira and H. A. C. Braga, “A high power factor single-phase rectifier based on a current multilevel buck converter,” pp. 180-185, in proc. 6th Brazilian Power Electron. Conf.(COBEP’01), Florianopolis, Brazil, Nov. 2001

[12] F.L.Luo and H. Ye. “Hybrid split capacitors and split inductors applied in positive output super-lift Luo-converters”, IET Power Electron., vol. 6, no. 9, pp.1759-1768,2013