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# Modified Step-Up or Step-Down DC-AC Converter without Intermediate Power Stage

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**ABSTRACT:** This paper introduces a new dc-ac converter with the feature that it produces an output voltage higher or lower than the input dc voltage without an intermediate power stage or transformers. This inverter is intended to be used in UPS design whenever an AC voltage larger than DC link voltage is needed, with no need of second power stage or transformers. The current ripple analysis is also done. In buck inverter the instantaneous average output voltage is always lower than the input voltage. The main objective of this paper is to analyze the circuit to get the output voltage lower or higher than the input voltage with corresponding duty cycle. By evaluating the simulation results inverter produces higher or lower voltage depends on the duty cycle.

**KEYWORDS:** DC-AC converter, switching cell

## 1. INTRODUCTION

The conventional VSI that is a buck inverter is most important power converter topology. It is used in industrial applications. UPS design is more important. In buck inverter the instantaneous average output voltage is always lower than the input voltage. The aim of this project is to analyse the circuit to get the output voltage lower or higher than the input voltage with corresponding duty cycle. It is easy to obtain boost voltage with high static gain by employing two DC-DC boost converters and then convert it into AC, but there exist more power stages. The converter operates with step down or step up feature. The constructive aspect is similar to that of buck inverter. The proposed inverter topology is similar to a H-bridge inverter topology, its output is square waveform. According to the inductor value triangular waveform also generated. This structure is composed of an input voltage source  $V_i$ , a high frequency filter formed by  $L_f$  and  $C_f$ , a load resistance  $R_o$ , and two switching cells whose elements are  $S_1, D_1, C_1, S_2, D_2$  &  $L_1$  and  $S_3, D_3, C_2, S_4, D_4$  &  $L_2$  respectively. Several modulation strategies can be applied to control the proposed converter, a bipolar modulation scheme is employed. When an output voltage higher than the input one is needed we have to select the duty cycle above 0.5. When an output voltage is lower than the input one is needed then we have to select duty cycle below 0.5. The advantage of proposed inverter is we have to decide the output voltage higher or lower than the input depending on the duty cycle. To analyse a four quadrant DC to AC switched mode inverter using buck-boost DC to DC converter, referred to as buck-boost inverter. The attribute of this inverter topology is that it naturally generates an AC output voltage lower or larger than the dc input voltage, depending on duty cycle. Like the buck and boost converters, the operation of the buck-boost is best understood in terms of the inductor's "reluctance" to allow rapid change in current. From the initial state in which nothing is charged and the switch is open, the current through the inductor is zero. When the switch is first closed, the blocking diode prevents current from flowing into the right hand side of the circuit, so it must all flow through the inductor. However since the inductor doesn't like rapid current change, it will initially keep the current low by dropping most of the voltage provided by the source. Over time, the inductor will allow the current to slowly increase by decreasing its voltage drop. Also during this time, the inductor will store energy in the form of a magnetic field.

Paper is organized as follows. Section II describes the main objective to generate higher or lower voltage depending on instantaneous duty cycle. It describes the Control Scheme Of Bipolar Modulator Applied to the Proposed Converter & Waveforms obtained for bipolar modulation: (a) modulator signal and triangular carrier signal; (b) signals applied in switches  $S_1$  and  $S_4$  (c) signals applied in switches  $S_2$  and  $S_3$ . circuit diagram and operating principle is given in Section III. Section IV presents design parameters and section v presents simulation showing results of images tested. Finally, Section VI presents conclusion.

**II. PROPOSED SYSTEM**

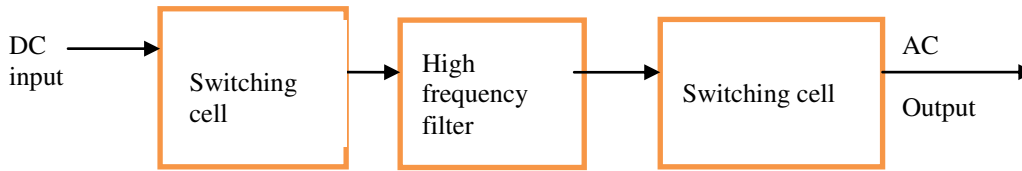


Fig 2.1 Block Diagram Of Proposed Converter

The main objective of this work is to generate higher or lower voltage depending on instantaneous duty cycle. It uses only two switching cells including inductor, capacitor, diode, switches. The main feature of this work is to generate higher or lower voltage without using any intermediate stage or transformers. The control strategy used in this inverter topology is bipolar modulation scheme of the bipolar modulator to proposed converter is given in fig 2.2

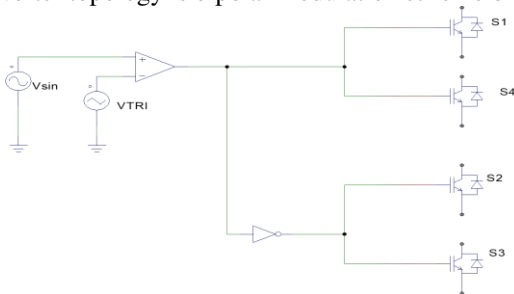


Fig 2.2 Control Scheme Of Bipolar Modulator Applied to the Proposed Converter

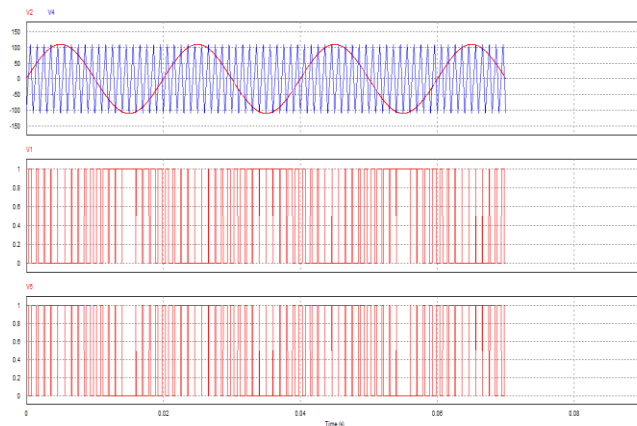


Fig 2.3 Waveforms obtained for bipolar modulation:(a) modulator signal and triangular carrier signal; (b) signals applied in switches  $S_1$  and  $S_4$ ; (c) signals applied in switches  $S_2$  and  $S_3$ .

Bipolar modulation is used in this inverter, several control strategies can be used like space vector, unipolar etc.. The control unit creates the bipolar switching due to its simplicity.

**III CIRCUIT DIAGRAM AND OPERATING PRINCIPLE**

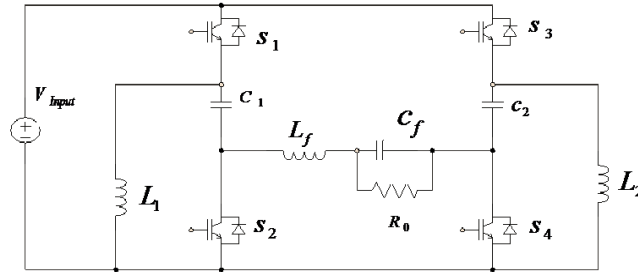


Fig 3.1 Circuit Diagram

This structure is composed of an input voltage source  $V_i$ , a high frequency filter formed by  $L_f$  and  $C_f$ , a load resistance  $R_o$ , and two switching cells whose elements are  $S_1, D_1, C_1, S_2, D_2, L_1$  and  $S_3, D_3, C_2, S_4, D_4, L_2$  respectively. Circuit is shown in figure.4.4. When an output voltage higher than the input one is needed we have to select the duty cycle above 0.5. When an output voltage is lower than the input one is needed then we have to select duty cycle below 0.5. The advantage of this inverter is we have to decide the output voltage higher or lower than the input depending on the duty cycle. From the study of equivalent circuits of the system, two particular cases were chosen, first refers to the system operation with a duty cycle higher than 0.5 and the second system operates with a duty cycle lower than 0.5. The system operates with duty cycle greater than 0.5 gives greater output voltage than input and the system operates with duty cycle less than 0.5 gives lower output voltage than input. Equivalent circuit for duty cycle greater than 0.5 during on time is shown in figure.3.2 & equivalent circuit for duty cycle less than 0.5 during on time is shown in figure.3.3.

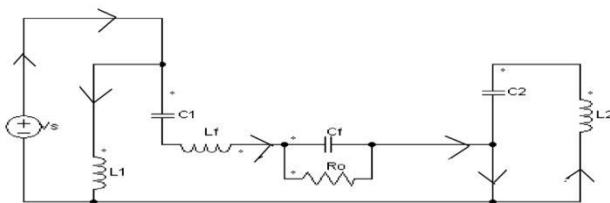


Fig 3.2 Equivalent circuits for duty cycle greater than 0.5 during on time

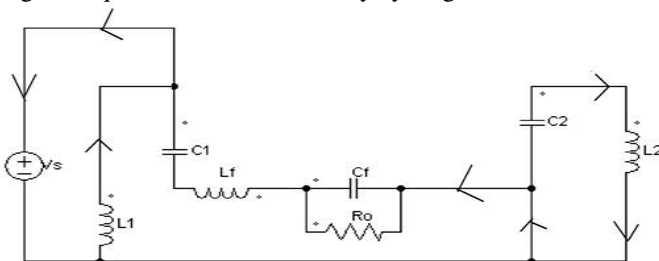


Fig 3.3 Equivalent circuits for duty cycle lower than 0.5 during on time

#### IV DESIGN PARAMETERS

$\frac{v_{out}}{v_{in}} = \frac{D}{1-D}$ , Where  $v_{out}$  is the output voltage,  $v_{in}$  is the input voltage & D is the instantaneous duty cycle.

From this equation we get,

boost voltage, if  $D > 0.5$ .

buck voltage, if  $D < 0.5$ .

Voltage gain:  $\frac{v_{out}}{v_{in}}$ .

It is clear that from the equations of output capacitor & inductor does not depend on duty cycle.

Switching frequency = 20KHz

$$\text{Duty ratio} = \frac{T_{on}}{T} = 0.62.$$

$$T = \frac{1}{f} = \frac{1}{20000} = 5 \times 10^{-5}.$$

$$T_{on} = 3.15 \times 10^{-5}.$$

From the design of high frequency filter

$$L = \frac{K}{4\pi f}, \text{ Assume the value of } k \text{ as } 400$$

$$L = 1.5 \times 10^{-5}$$

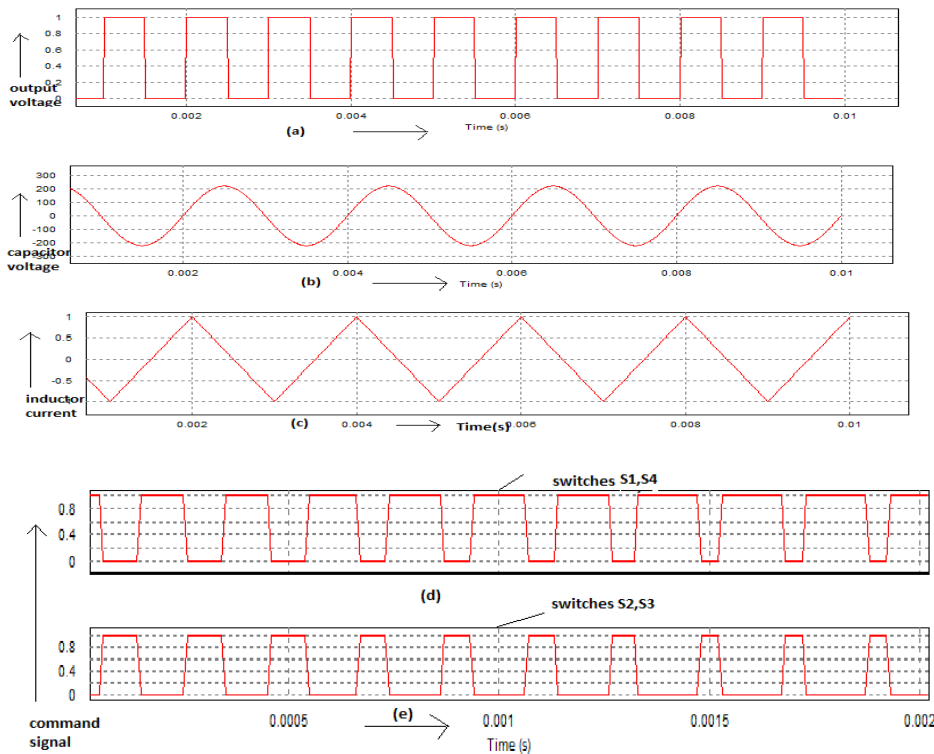


Fig 3.4 Key waveforms showing (a) voltage across the terminals,(b)voltage across the output capacitor,(c) current through the output inductor,(d) command signals applied tothe switches  $S_1$ & $S_4$ ,(e) command signal applied to switches  $S_2$ & $S_3$

Table 1 showing component values

COMPONENTS	VALUES
Capacitance $C_1$	10 $\mu$ F
Capacitance $C_2$	10 $\mu$ F
Inductance $L_1$	0.005 $\mu$ H
Inductance $L_2$	0.005 $\mu$ H
Capacitance $C_f$	5 $\mu$ F
Inductance $L_f$	1.5mH

Resistance $R_0$	12Ω
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V SIMULATION RESULT

A. EXISTING TOPOLOGY

The conventional VSI referred to a buck inverter is one of the existing topology. Here the output voltage is lower than the input voltage, thus it has limitations in many applications. When an output voltage greater than the input voltage is needed, a boost converter must be used in between the DC source and the inverter. Figure.5.1 shows the conventional VSI. The simulation results are also shown in figure.5.2.

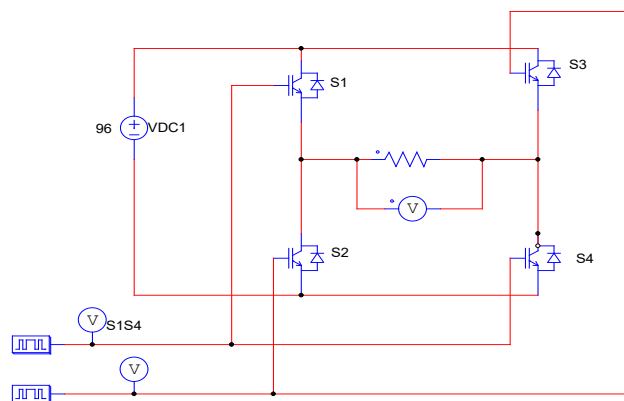


Fig 5.1 conventional VSI

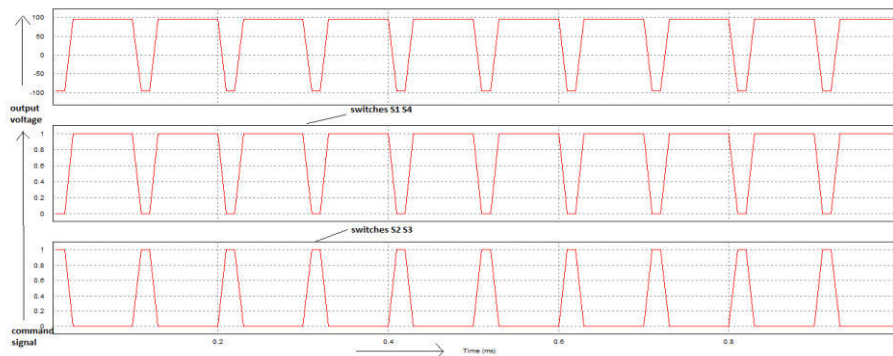


Fig 5.2 simulation result of conventional VSI

The above simulation result showing output voltage and pulses given to the switches. Input voltage given to the inverter is 96V, the output voltage obtained is 95V. To overcome this problem we have to design a circuit to boost the input voltage by adding a DC-DC boost converter in between DC source and inverter in figure 5.3. In this implementation power and voltage levels involved results in high volume, weight, cost and reduced efficiency. Therefore we have to implement another circuit without having intermediate power stage or transformers.

B. MODIFIED STEPUP OR STEPDOWN DC-AC CONVERTER

This introduces a new dc-ac converter with the feature that it produces an instantaneous output voltage higher or lower than the input dc voltage without an intermediate power stage or transformers. This feature is provided by using one switching cell including two switches, two diodes, one inductor, and one capacitor on each inverter leg. This structure is composed of an input voltage source  $V_i$ , a high frequency filter formed by  $L_f$  and  $C_f$ , a load resistance  $R_0$ , and two switching cells, whose elements are  $S_1, D_1, C_1, S_2, D_2$  and  $L_1$  and  $S_3, D_3, C_2, S_4, D_4$  and  $L_2$  respectively.

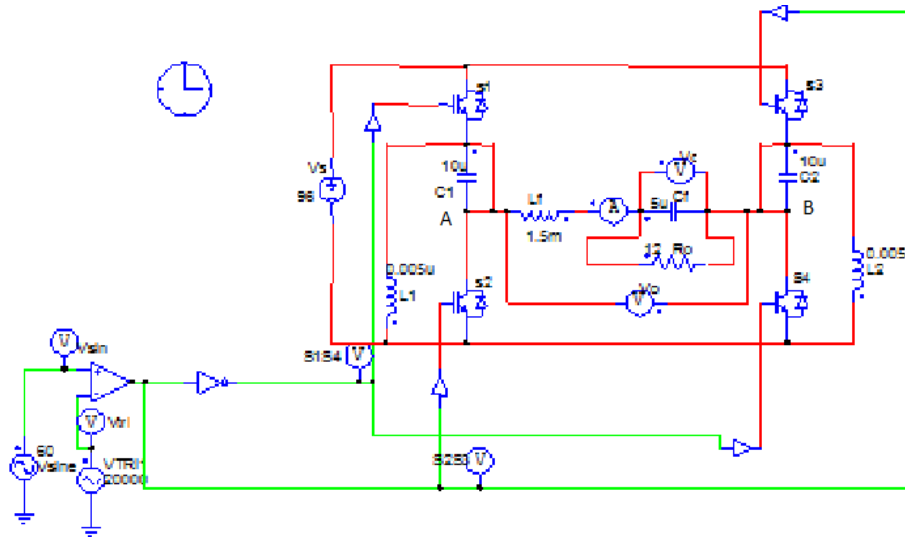


Fig 5.3 simulation diagram of modified step up or step down DC-AC converter

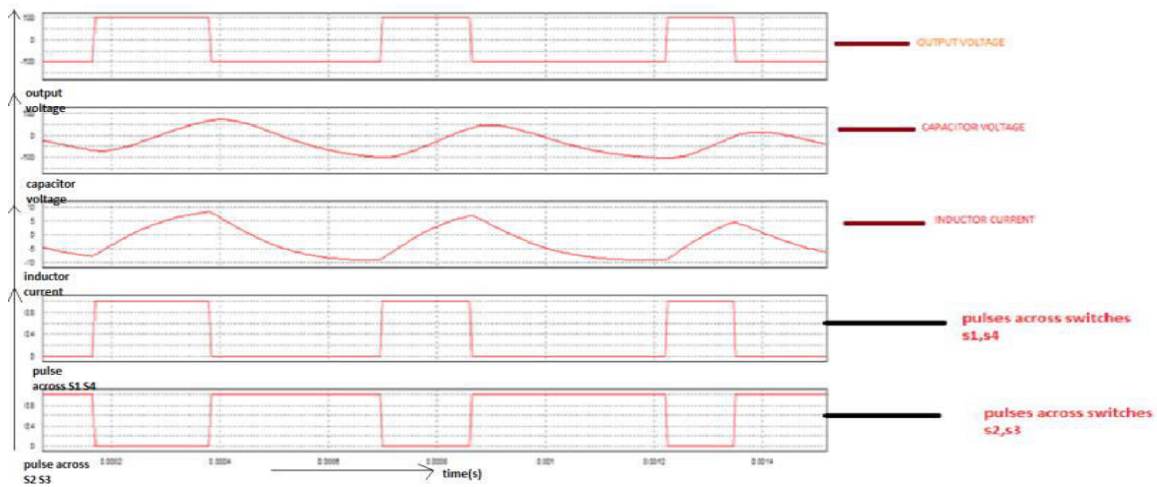


Fig 5.4 Simulated output of the output voltage across the terminal AB, output voltage across the capacitor  $C_f$ , output current across inductor  $L_f$

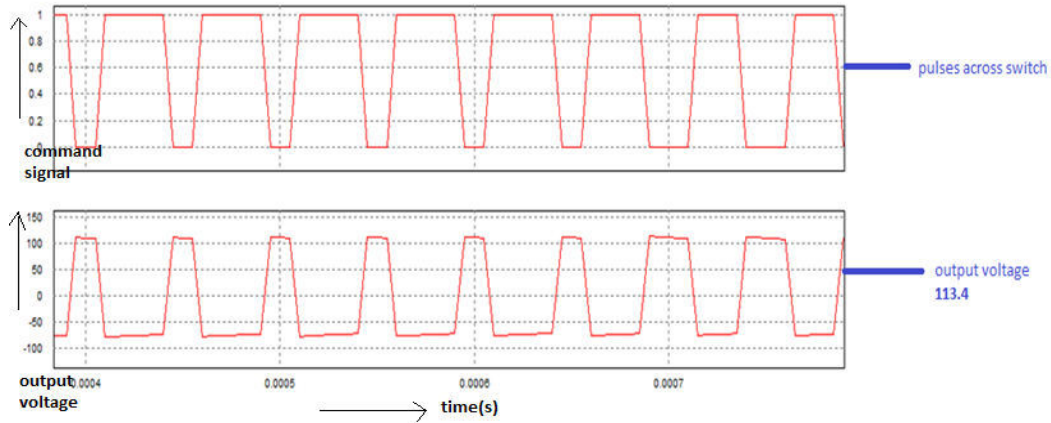


Fig 5.5 Simulated Result Showing Boosted Output Voltage

This shows the output voltage waveform across the terminals AB when the duty cycle is above 0.5. The voltage obtained across the terminal is 113.4V when an input of 96V is given. Thus the output waveforms give a clear picture about the proposed circuit

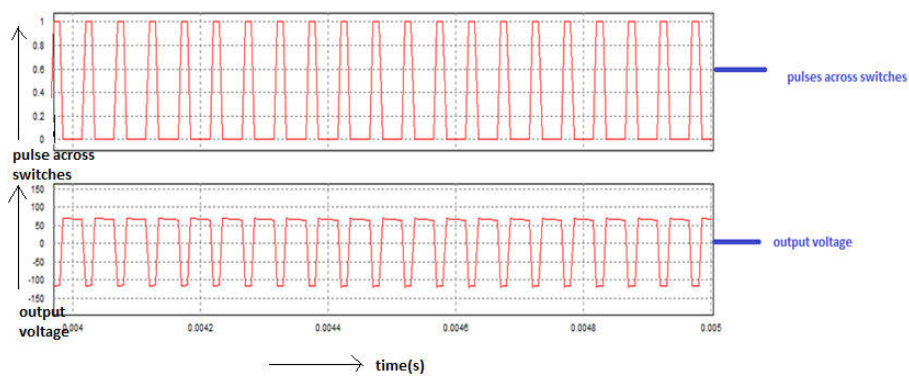


Fig 5.6 simulated result showing buck output voltage

This shows the output voltage waveform across the terminals AB when the duty cycle is below 0.5. The voltage obtained across the terminal is 70.1V when an input of 96 V is given.

Table 2 showing results by varying duty cycle

Duty cycle	Input voltage	Output voltage
Higher than 0.5	96v	113.4v
Lower than 0.5	96v	70.1v

Table 3 showing output voltage comparison from two circuits






Table 4 showing static gain results

Input voltage	Output voltage	Static gain
96v	113.4v	1.18

Table 5 Showing Results of Current Ripple

Type	Current ripple
Boost converter	1.728
Buck converter	1.28

## VI CONCLUSION

This work presented a new topology for dc–ac converters whose main feature is its capacity to provide an instantaneous output voltage higher or lower than the input voltage without an intermediate power stage or transformer. The value of static gain is obtained. This circuit is cost effective as it consist of less number of power stages and proposed converter is weightless, the value of output capacitance and inductance does not depends on the duty cycle. The conventional VSI that is a buck inverter is most important power converter topology. In buck inverter the instantaneous average output voltage is always lower than the input voltage. In this modified design we have generate higher or lower voltage depending on the instantaneous duty cycle. The proposed inverter topology is similar to a H-bridge inverter topology, its output is square waveform. According to the inductor value triangular waveform also generated. The simulation work has been finished and the future work is to implement the hardware. The control circuit design has to be made based on switching in the inverter. Bipolar modulation based control strategy is used. The main aim of this project is to achieve higher or lower output voltage depending on the duty cycle without using any intermediate stage or transformer.

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