# *Single-Input Multiple Output High efficient Boost DC–DC Converter*

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***Abstract*—The aim of this study is to develop a high-efficiency single-input multiple output (SIMO) dc–dc converter. The proposed converter can boost the voltage of a low-voltage input power source to a controllable high-voltage dc bus and middle-voltage output terminals and low voltage output terminals. The high-voltage dc bus can take as the main power for a high-voltage dc load or the front terminal of a dc–ac inverter. Moreover, middle-voltage output terminals can supply powers for individual middle-voltage dc loads or for charging auxiliary power sources (e.g., battery modules).and low voltage can be used for charging battery. In this study, a coupled-inductor based dc–dc converter scheme utilizes only one power switch with the properties of voltage clamping and soft switching, and the corresponding device specifications are adequately designed. As a result, the objectives of high-efficiency power conversion, high stepup ratio, and various output voltages with different levels can be obtained. Also a series forward flyback converter is integrated to this converter for producing isolated output. Some experimental results via a kilowatt-level prototype are given to verify the effectiveness of the proposed SIMO dc–dc converter in practical applications..**

***Keywords-High efficient,High voltage gain,; Flyback converter,series- forward flyback converter,SIMO converter***

## I. INTRODUCTION

In order to protect the natural environment on the earth, the development of clean energy without pollution has the major representative role in the last decade. By dealing with the issue of global warning, clean energies, such as fuel cell (FC), photovoltaic, and wind energy, etc., have been rapidly promoted. Due to the electric characteristics of clean energy, the generated power is critically affected by the climate or has slow transient responses, and the output voltage is easily influenced by load variations.For example Photovoltaic (PV) sources are used today in many applications from satellite power systems to battery chargers and home appliances. The power produced by a solar panel depends on two factors;irradiation,and temperature. As irradiation and temperature levels change rapidly, the voltage produced fluctuates and becomes inconstant.

A converter is therefore required to produce a constant voltage that is matched to the requirements of the load and supplied efficiently. Therefore dc–dc converters with steep voltage ratio are usually required in many industrial applications. The conventional boost converters can not provide such a high dc-voltage ratio due to the losses associated with the inductor, filter capacitor, main switch, and output diode.As a result, the conversion efficiency is degraded, and the electromagnetic interference (EMI) problem is severe under this situation.Also if voltage requirement of the load is very large various single-input single-output dc–dc converters with different voltage gains are combined to satisfy the requirement of various voltage levels, so that its system control is more complicated and the corresponding cost is more expensive. The motivation of this study is to design a single-input multiple-output (SIMO) converter for increasing the conversion efficiency and voltage gain, reducing the control complexity, and saving the manufacturing cost.This study presents a newly designed SIMO converter(Boost converter) with a coupled inductor also series forward flyback converter is integrated to this converter for isolation purpose. On the other hand, an isolation type converter has an advantage of the safety and system reliability, in spite of the high power conversion efficiency. Therefore, many emerging applications including renewable energy conditioner demands the isolation requirement in their design specification.So in this paper also include series forward flyback converter for producing isolated outputs.So that isolated outputs can be useful for Multilevel inverter.

## II. LITERATURE SURVEY

In paper [3] Patra *et al* presented a SIMO dc–dc converter capable of generating buck, boost, and inverted outputs simultaneously. However, over three switches for one output were required. This scheme is only suitable for the low output voltage and power application, and its power conversion is degenerated due to the operation of hard switching.In paper [4] Nami *et al* proposed a new dc–dc multi-output boost converter, which can share its total output between different series of output voltages for low- and high-power applications. Unfortunately, over two switches for one output were required, and its control scheme was complicated. Besides, the corresponding output power cannot supply for individual loads independently. In paper [5] Chen *et al* .investigated a multiple-output dc–dc converter with shared zero-currentswitching (ZCS) lagging leg. Although this converter with the soft-switching property can reduce the switching losses, this combination scheme with three full-bridge converters is more complicated, so that the objective of high-efficiency power conversion is difficult to achieve, and its cost is inevitably increased.

This study presents a newly designed SIMO converter with a Series Forward Flyback Converter fo isolation purposes. The proposed converter uses one power switch to achieve the objectives of high efficiency power conversion, high step-up ratio, and different output voltage levels. In the proposed SIMO converter, the techniques of soft switching and voltage clamping are adopted to reduce the switching and conduction losses via the utilization of a low-voltage-rated power switch with a small $R_{DS(on)}$ . Because the slew rate of the current change in the coupled inductor can be restricted by the leakage inductor, the current transition time enables the power switch to turn ON with the ZCS property easily, and the effect of the leakage inductor can alleviate the losses caused by the reverse-recovery current. Additionally, the problems of the stray inductance energy and reverse-recovery currents within diodes in the conventional boost converter also can be solved, so that the high-efficiency power conversion can be achieved. The voltages of middle-voltage output terminals can be appropriately adjusted by the design of auxiliary inductors; the output voltage of the high-voltage dc bus can be stably controlled by a simple proportional-integral (PI) control.

## III. PROPOSED TOPOLOGY

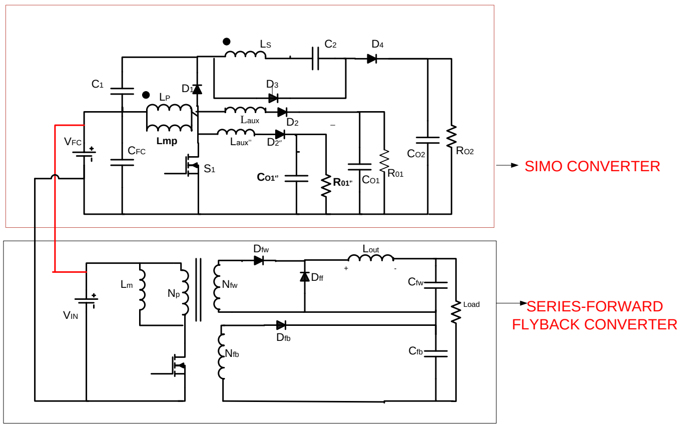


Fig 1.proposed topology circuit

Figure contains a SIMO coverter(ie,single input three output converter)and a series forward flyback converter also integrated for isolated outputs)

The Proposed converter has the features of converting single input to three level output[1] using single switch also a series forward flyback converter is integrated for isolation purpose. On the other hand, an isolation type converter has an advantage of the safety and system reliability, in spite of the high power conversion efficiency. Therefore, many emerging applications including renewable energy conditioner demands the isolation requirement[2] in their design specification.So in short the proposed converter has the features of single input to three level output using single switch,and also isolate output from input power supply.

### A. *The single input three output converter has 6 modes of operation.*

- Mode 1

In this mode, the main switch $S_1$ was turned ON for a span, and the diode $D_4$ turned OFF. Because the polarity of the windings of the coupled inductor $T_r$ is positive, the diode $D_3$ turns ON. The secondary current $i_{Ls}$ reverses and charges to the middle voltage capacitor $C_2$ . When the auxiliary inductors $L_{aux}$ and $L_{aux}$' releases its stored energy completely, and the diode $D_2$ and $D_2$' turns OFF, this mode ends.

- Mode 2

At time $t = t_1$ , the main switch $S_1$ is persistently turned ON. Because the primary inductor $L_P$ is charged by the input power source, the magnetizing current $i_{Lmp}$ increases gradually in an approximatelynlinear way. At the same time, the secondary voltage $v_{Ls}$ charges the middle-voltage capacitor$C_2$ through the diode $D_3$ . Because the auxiliary inductor $L_{aux}$ and $L_{aux}$' releases its stored energy completely.

- Mode 3

At time $t = t_2$ , the main switch $S_1$ is turned OFF. When the leakage energy still released from the secondary side of the coupled inductor, the diode $D_3$ persistently conducts and releases the leakage energy to the middle-voltage capacitor $C_2$ . When the voltage across the main switch $v_{S1}$ is higher than the voltage across the clamped capacitor $V_{C1}$ , the diode $D_1$ conducts to transmit the energy of the primary-side leakage inductor $L_{kp}$ into the clamped capacitor $C_1$ . At the same time,partial energy of the primary-side leakage inductor $L_{kp}$ is transmitted to the auxiliary inductor $L_{aux}$ and $L_{aux}$', and the diode $D_2$ and $D_2$' conducts. Thus, the current $i_{L\,aux}$ passes through the diode $D_2$ to supply the power for the output load in the auxiliary circuit. When the secondary side of the coupled inductor releases its leakage energy completely, and the diode $D_3$ turns OFF, this mode ends.

- .Mode 4

At time $t = t_3$ , the main switch $S_1$ is persistently turned OFF. When the leakage energy has released from the primary side of the coupled inductor,the secondary current $i_{LS}$ is induced in reverse from the energy of the magnetizing inductor $L_{mp}$ through the ideal transformer, and flows through the diode $D_4$ to the HVSC. At the same time, partial energy of the primaryside leakage inductor $L_{kp}$ is still persistently transmitted to the auxiliary inductor $L_{aux}$ and $L_{aux}$', and the diode $D_2$ and $D_2$' keeps to conduct. Moreover, the current $i_{L\,aux}$ passes through the diode $D_2$ and $D_2$'to supply the power for the output load in the auxiliary circuits.

- Mode 5

At time $t = t_4$ , the main switch $S_1$ is persistently turned OFF, and the clamped diode $D_1$ turns OFF because the primary leakage current $i_{Lkp}$ equals to the auxiliary inductor current $i_{L\,aux}$ and $i_{L\,aux'}$ .

- .Mode 6

At time $t=t_5$ , this mode begins when the main switch $S_1$ is triggered. The auxiliary inductor current $i_{L\,aux}$ and $i_{L\,aux'}$ needs time to decay to zero, the diode $D_2$ persistently conducts. In this mode, the input power source, the clamped capacitor $C_1$, the secondary winding of the coupled inductor $Tr$, and the middle-voltage capacitor $C_2$ still connect in series to release the energy into the HVSC through the diode$D_4$ .The main switch $S_1$ is turned ON under the condition of ZCS and this soft-switching property is helpful for alleviating the switching loss.

*B.Similarly the Series forward flyback converter has 4 Modes of operation.*

- Mode 1

Current flows to the magnetizing inductance and the primary winding $N_p$ as a result of turning ON switch Q. The primary current is transferred to the secondary $N_{fw}$ coil of the forward converter via the magnetic linkage. Then, the ac power is rectified into dc which load requires through a forward diode $D_{fw}$ and a low-pass filter $L_{out}$ and $C_{fw}$.Since a flyback diode $D_{fb}$ is reverse biased,the capacitor $C_0$ provides the load current during this mode.

- Mode 2

When switch Q is turned OFF, a forward diode $D_{fw}$ is reverse biased and the energy stored in Lout is transferred to the load by the freewheeling current via $D_{ff}$, and at the same time, the energy magnetically stored at $L_m$ is also supplied to load through $D_{fb}$ of the flyback converter. Thus, all the freewheeling current in magnetic devices decreases linearly.

- Mode 3

The forward converter starts to operate in DCM when all the energy in $L_{out}$ is discharged, and then a freewheeling diode $D_{ff}$ is reverse biased. The energy only stored in $L_m$ is supplied to load through the flyback converter.

- Mode 4

The transformer of the forward–flyback converter is demagnetized completely during this period and the output voltage is maintained by the discharge of the output capacitors $C_{fw}$and $C_{fb}$ . All the rectifier diodes are reverse biased

## IV. DESIGN CONSIDERATION

### *A. .Single input three level output converter*

Input $V_{FC}$ is taken as 12 v.
We want to produce $V_{01}$=28 v,$V_{02}$=200 v,$V_{01}$'=14 v

$$R_{01\min} = \frac{{G_{vL}}^2 {V_{FC}}^2}{P_{1\max}} \longrightarrow R_{01} = 7.84\Omega \quad (1)$$

$$R_{02\min} = \frac{{G_{VH}}^2 {V_{FC}}^2}{P_{2\max}} \longrightarrow R_{02} = 36.36\Omega \quad (2)$$

$$R_{01\min'} = \frac{{G_{vL}}'^2 {V_{FC}}'^2}{P_{1\max}'} \longrightarrow R_{01'} = 2\Omega \quad (3)$$

By using the below equation,

$$G_{VL} = \frac{V_{01}}{V_{FC}} = \frac{2}{(1-d_1)+\sqrt{(1-d_1)^2+\left[\frac{8L_{aux}}{R_{01}T_S}\right]}} \quad (4)$$

We can find $L_{aux}$ , $L_{aux}'$ by substituting corresponding $R_{01,}$ $R_{01'}$ in the above equation
$ie, L_{aux}$ =2μH $\quad L_{aux'}$ = 4.5 μH

In the proposed SIMO converter, the electric charge variation $\Delta Q1$ of the filter capacitor for the auxiliary circuit can be represented as$\Delta Q_1=(V_{01}/R_{01})(d_1 - d_x)T_S = C_{01}\Delta V_{01}$. By substituting$d_1$= 0.64, $R_{01}$ =7.84 Ω, $T_s$ = 10 μs, and $L_{aux}$ = 2 μH into (17), the duty cycle dx can be calculated as 0.11. If one sets the voltage ripple of VO1 to be less than 1%, the value of CO1 should be selected over 67.6 μF by substituting $d_1$ = 0.64, $d_x$ = 0.11, $R_{01}$= 7.84 Ω, $F_S$= 100 kHz, and $V_{01}$ = 28 V into the function of $C_{01} = (d_1 - d_x)/[(R_{01}F_s)(\Delta V_{01}/V_{01})]$. Moreover the electric charge variation of the filter capacitor $\Delta Q2$ for the HVSC can be expressed as $\Delta Q2=(V_{02}/R_{02})d_1T_S=C_{02}c\Delta V_{02}$. and the ripple of the output voltage $V_{02}$ can be rearranged as $\Delta V_{02}/V_{02} = d_1/(R_{02}C_{02}F_s)$. By substituting $F_s$ = 100 kHz, $d_1$ = 0.64, $R_{02}$= 36.36 Ω, and $V_{02}$=200V into the function of $C_{02} = (d_1)/[(R_{02}F_s)(\Delta V_{02}/V_{02})]$,The value of $C_{02}$should be chosen over 17.6 $\mu$F with the constraint on the output voltage ripple to be less than 1%. According to the previous consideration, the values of $C_{01}$= 100$\mu$F and $C_{02}$= 20 $\mu$F and $C_{01'}$= 62.75$\mu$F

Due to a high-switching frequency ($F_s$ = 100 kHz) in the proposed SIMO converter, the factors of lower equivalent series resistance and faster dynamic response should be considered in the design of the clamped capacitor $C_1$ and the middle-voltage capacitor $C_2$ for reducing the capacitor voltage ripples. In this study, metalized-polyester film capacitors are adopted for $C_1$ and $C_2$ for satisfying the fast charge and discharge property.In order to further minimize the current and voltage ripples imposed to the main switch $S1$ and the diodes $D_3$ and $D_4$, the cutoff frequencies of the $L_P - C_1$ and $L_S - C_2$filters are taken to be at least ten times smaller than the switching frequency. According to the previous consideration, the values of $C_1$and $C_2$are, respectively, chosen as 85 and 10 $\mu$F in theproposed SIMO converter so that the corresponding resonant frequencies are$F_{01} \equiv 1/\left(2\pi\sqrt{L_P C_1}\right) \cong 9.97$kHZ. and $F_{02} \equiv 1/\left(2\pi\sqrt{L_S C_2}\right) \cong 5.81$kHZ.

### *B. .Series forward flyback converter*

For high efficiency without core saturation,$Kn$= 0.4 With the selected $Kn$, the winding number is chosen as $Np$: $N$fw : $N$fb = 20 : 150 : 60. Critical magnetizing inductance for DCM is derived as

$$L_{m(\max)} = \frac{n2^2 R_{fb\min}(1-DB_{\max})^2}{2 f_s} = 274\mu H \quad (5)$$

The maximum filter inductance of the forward's output is determined as

$$L_{out(\max)} = \frac{RL_{\min}(1 - DB_{\max})}{2 f_s} \qquad (6)$$

The inductance utilized in the hardware prototype DCM is *L*out = 1.7mH.

The secondary-diode selection should consider voltage and current stresses, reverse recovery characteristics, etc. Voltage stresses of the forward, freewheeling, and flyback diodes are, respectively,shown in

$$\left.\begin{aligned} V_{Dfw} &= V_{ofb(\frac{n_2}{n_1})} + V_{ofw} = 207v \\ V_{Dff} &= \frac{V_{in}}{n_1} = 300v \\ VD_{fb} &= (V_{Ofb} + VL_{out})\frac{n_1}{n_2} + V_{ofb} = 233v \end{aligned}\right\} \qquad (7)$$

V SIMULINK BLOCK DIAGRAM

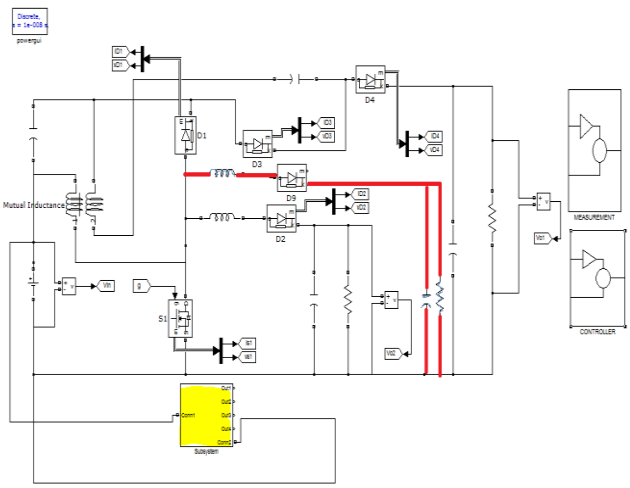


Fig 2.Simulink block diagram

Fig 2 shows the simulink block diagram of proposed converter.ie,SIMO converter integrated with series-forward flyback converter.The yellow colour shows the subsystem representing series- forward flyback converter

VI . SIMULATION RESULTS

*C. .Three output voltages from converter*

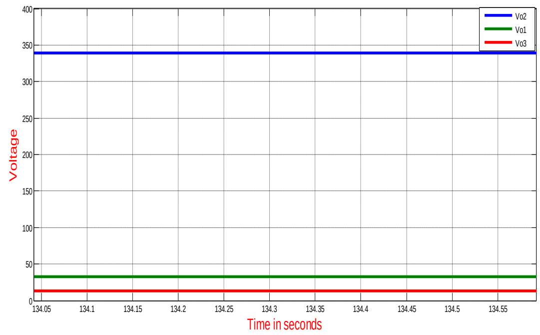


Fig 3 Three output voltages from converter

Fig 3 shows simulated waveform of three output voltages (200v,28v,14v)from a single input by using single switch.

*D. Output from series- forward flyback converter*

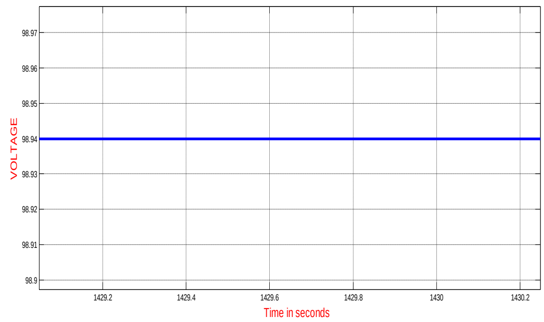


Fig 4 Output voltage from series forward flyback converter

Fig 4 shows the output voltage(99v) of series forward- flyback converter used for isolated outputs.ie Series-forward flyback converter also produce boosted output voltage.

III EXPERIMENTAL RESULTS

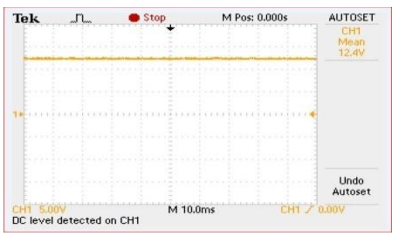


Fig 3 .Input voltage=12 v

Fig 3 shows the input voltage given to the converter.ie,12 v

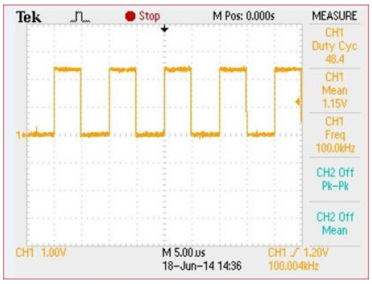


Fig 5 PIC pulse

Fig 5 shows the pulse given by the PIC(pwm pulse)with duty ratio 48.4

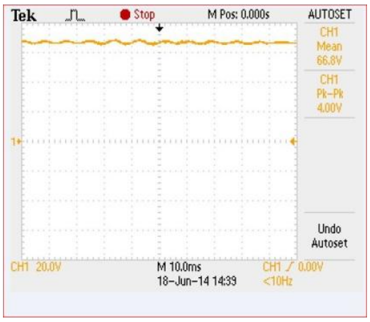


Fig 6 $V_{02}$

Fig 6 shows the one of the output voltage of SIMO converter(ie,66.8).The designed output voltage is 200 v.But experimentally can not produce that much voltage.Due to losses and unavailability of the high capacity equipments.

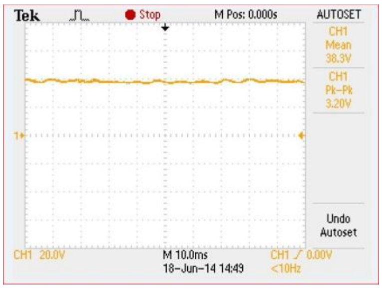


Fig 7 $V_{01}$

Fig 7 shows the second output voltage from the converter (ie ,38.3).

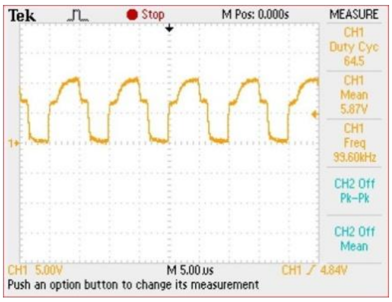


Fig 4 $V_{GS}$

Fig 4 shows the gate source voltage across the switch(MOSFET)

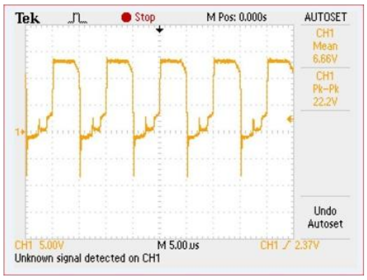


Fig 8 $V_{D1}$

Fig 8 shows the voltage across the diode D1.

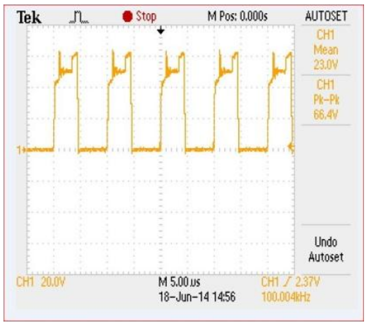


Fig 9 $V_{D2}$

Fig 9 shows the voltage across the diode D2.

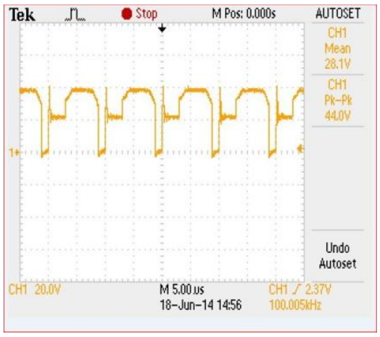


Fig 10 $V_{D3}$

Fig 10 shows the voltage across the diode D3.

## CONCLUSION

This paper has successfully developed a high-efficiency Single input three output dc-dc converter with integrated series forward flyback converter.And this coupled-inductor-based converter was applied well to a single-input power source plus three output terminals composed of an auxiliary battery modules and a high-voltage dc bus. The proposed SIMO converter is suitable for the application required one common ground, which is preferred in most applications. The major scientific contributions of the proposed SIMO converter are recited as follows: 1) this topology adopts only one power switch to achieve the objective of high efficiency SIMO power conversion; 2) the voltage gain can be substantially increased by using a coupled inductor; 3) the stray energy can be recycled by a clamped capacitor into the auxiliary battery module or high-voltage dc bus to ensure the property of voltage clamping; 4)an auxiliary inductor is designed for providing the charge power to the auxiliary battery module and assisting the switch turned ON under the condition of ZCS; 5) the switch voltage stress is not related to the input voltage. so that it is more suitable for a dc power conversion mechanism with different input voltage levels; and 6)An isolation type converter has an advantage of the safety and system reliability, in spite of the high power conversion efficiency.7)By integrating series-forward flyback converter it can produce isolated outputs which can be successfully used for multilevel inverters. Therefore, many emerging applications including renewable energy conditioner demands the isolation requirement in their design specification.

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