International Journal of Engineering Research and Development
e-ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com
Volume 10, Issue 2 (February 2014), PP.100-105

Level Shifting Switched Capacitor Voltage Copier Circuits with Feedback Control

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Abstract:- Nowadays developments are occurring in the field of sustainable energy sources.Sustainable energy sources like photovoltaic systems and fuel systems require different levels of power supplies.Traditionally transformer or inductor based multiport dc-dc converters were used.But these converters have high electromagnetic interference and are larger in size.In this paper, a level shiftingswitched capacitor voltage copier circuits with feedback is introduced with less number of components. There are five circuits namely summation, subtraction, double, half and inverting circuitsSimulation has been carried out to study the performance of the proposed topology in MATLAB/SIMULINK environment. Simulation results analysed and results presented for circuit.

Keywords:- switched capacitor, voltage copier, THD

I. INTRODUCTION

In recent years many developments are taking in the field of sustainable energy sources. These energy sources like photovoltaic systems [2] are composed of sub modules. These sub modules require different levels of power supplies.Conventionally transformer based or inductor based multilevel dc-dc converters were used [3]-[5]. There are many drawbacks for these circuits which include the high component size and high electromagnetic interference.

In this paper, a level shiftingswitched capacitor voltage copier (SCVC) with feedback is introduced with less number of components and reduced total harmonic distortion [1]. The SCVC with feedback consist of five circuits. They are summation, subtraction, double [6], half [6], inverting [6] circuits. In all these circuits we have two switches, two diodes and one capacitor. In this paper, PWM technique is used and by this THD improved.Analyses of these circuits are done in MATLAB environment and simulation results are presented.

II. PROPOSED SYSTEM CONFIGURATION

The block diagram of proposed system is shown figure1. There are summation, subtraction, double, half and inverting circuit. There are two modes for all circuits. These circuits use only six to seven electronic components.

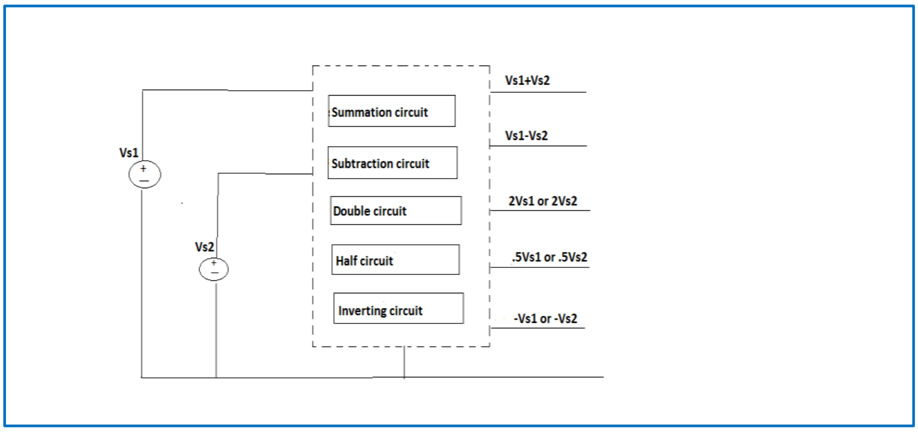


Fig 1: Proposed system configuration

Summationcircuit: Summation circuit is shown in figure2.In mode 1 $Q_1$is ON,Q_2 is OFF, D_1 is forward biased and D_2 is reverse biased. Capacitor C_1 charges to voltage V_{s1} .This is known as charging state. In mode 2$Q_2$is ON, Q_1 is OFF, D_2 is forward biased and D_1 is reverse biased. Capacitor C_1 discharging and capacitor C_2 is charging to voltage $V_{c1}+V_{s2}$.This is known as discharging state.The output of summation circuit is $V_{s1}+ V_{s2}$.

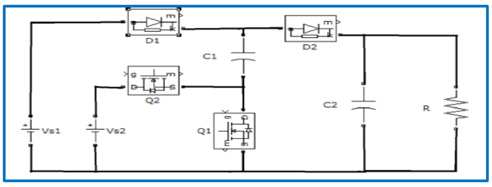


Fig 2: Summation circuit

Subtraction circuit ($V_{s1} > V_{s2}$): Subtraction circuit is shown in figure3. In mode 1 $Q_1$is ON, $Q_2$is OFF, D_1 is forward biased and D_2 is reverse biased. Capacitor C_1 charges to voltage V_{s1} -V_{s2} .This is known as charging state. In mode 2$Q_2$is ON, Q_1 is OFF, D_2 is forward biased and D_1 is reverse biased.Capacitor C_1discharging and capacitor C_2 is charging to voltage Vs_1-V_{s2}.This is known as discharging state.The output of subtraction circuit is V_{s1}- V_{s2} .

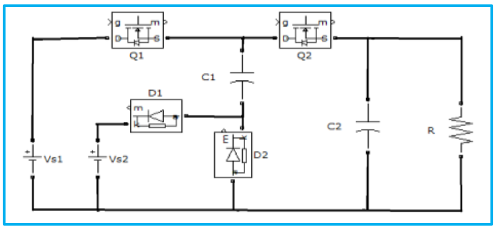


Fig 3: Subtraction circuit

Doublecircuit: Double circuit is shown in figure4. In mode 1 $Q_1$is ON, Q_2 is OFF, D_1 is forward biased and D_2 is reverse biased. Capacitor C_1 charges to voltage V_s .This is known as charging state. In mode 2 $Q_2$is ON, Q_1 is OFF, D_2 is forward biased and D_1 is reverse biased. Capacitor C_1 discharging and capacitor C_2 is charging to voltage Vc_1+V_s.This is known as discharging state. The output of double circuit is $2V_s$.

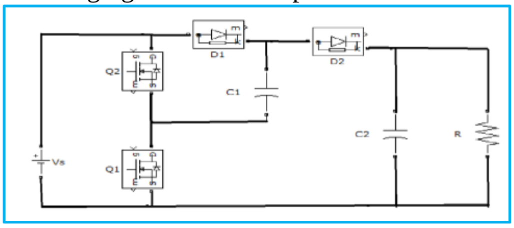


Fig 4: Double circuit

Half circuit: Half circuit is shown in figure5. In mode 1 $Q_1$is ON, Q_2 is OFF, D_1 is forward biased and D_2 is reverse biased. Capacitor $C_1$and capacitor C_2 equally charges to voltage.5V_s. In mode 2 $Q_2$is ON, Q_1 is OFF, D_2 is forward biased and D_1 is reverse biased. The voltage across capacitor C_2remains constant. The output of half circuit is .5V_s .

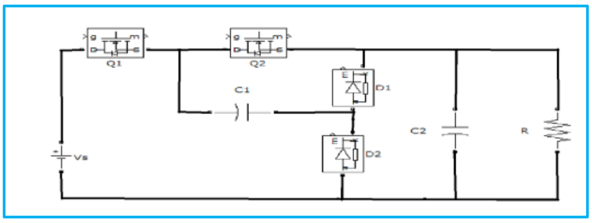


Fig 5: Half circuit

Invertingcircuit: Inverting circuit is shown in figure6. In mode 1 $Q_1$is ON, Q_2 is OFF, D_1 is forward biased and D_2 is reverse biased. Capacitor C_1charges to voltageV_s .This is known as charging state. In mode 2 $Q_2$is ON, Q_1 is OFF, D_2 is forward biased and D_1 is reverse biased. Capacitor C_1 discharging and capacitor C_2 is charging to voltage $V_s$with reverse polarity. Thisis known as discharging state. The output of inverting circuit is -V_s .

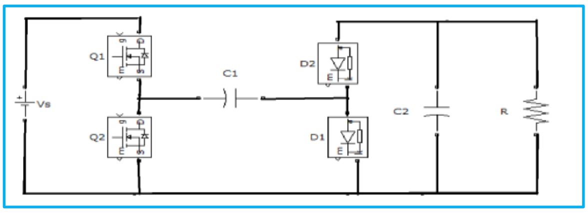


Fig 6: Inverting circuit

III. FEEDBACK CONTROL

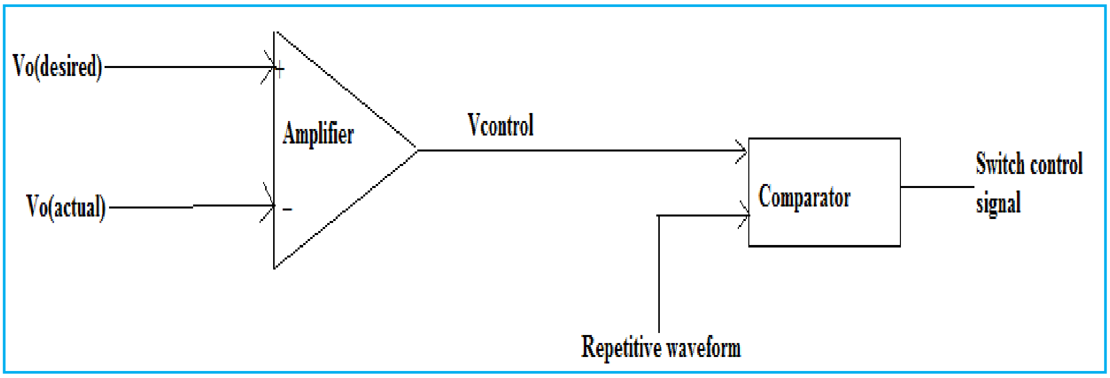


Fig 7: Block diagram of feedback control

Feedback control is provided to control the output voltage to the desired level. In a dc-dc converter with a given input voltage the average output voltage is controlled by adjusting the switch on and off durations. The control voltage is generally obtained by amplifying the error signal or difference between actual voltage and desired voltage. Any change in the input voltage is sensed as change in output voltage accordingly the error signal also changes. The error signal is used to change the duty ratio of the switching pulses to keep the voltage constant.

IV. SIMULATION RESULTS

The simulation result of proposed level shifting SCVC with feedback has been simulated in MATLAB SIMULINK.The switches Q_1 and Q_2 cannot be turned on simultaneously.They are triggered by a pair of half pulses. Gate signals for the switches Q_1 and Q_2, simulated waveforms of voltage across capacitor andoutput voltage are shown in figure. Gate signals to all the circuits are same.

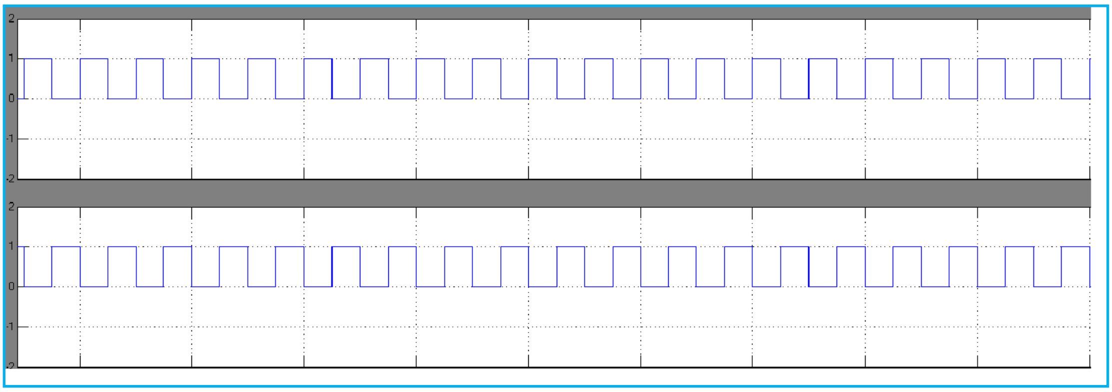


Fig 8:Gate pulses to switches Q_1 and Q_2

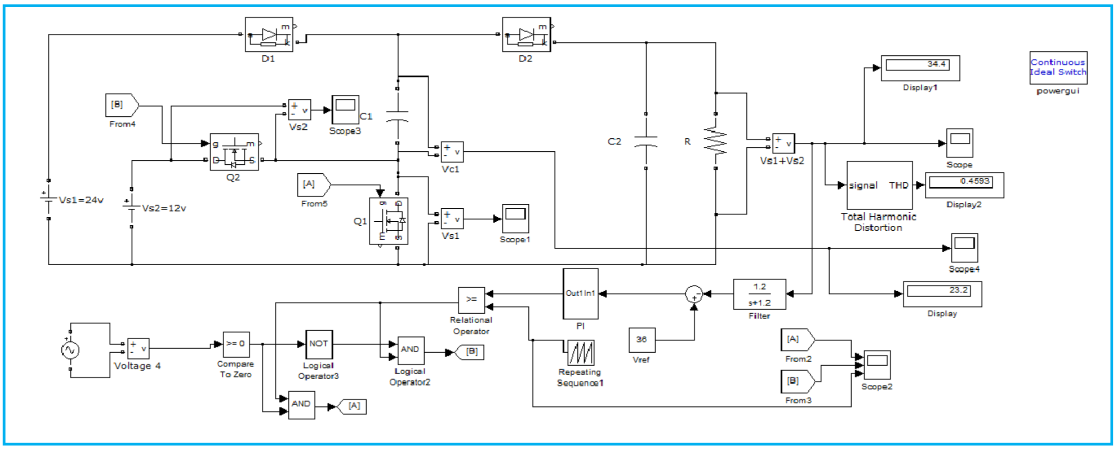
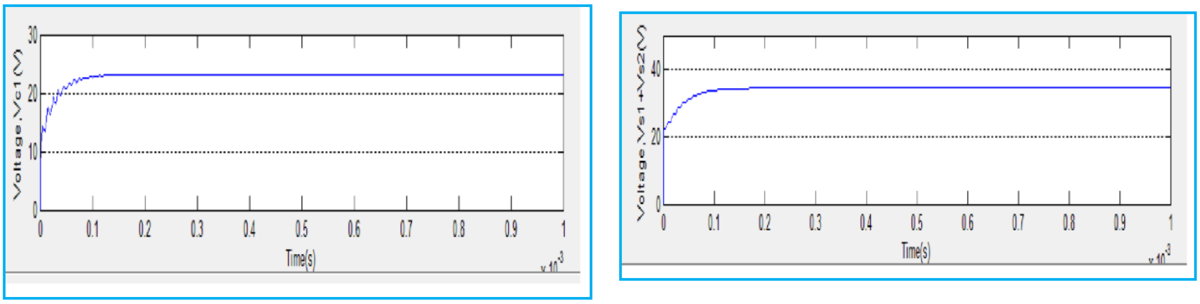


Fig 9: Simulink model of summation circuit



(a) **(b)**

Fig 10: (a) voltage across capacitor (b) output voltage for summation circuit

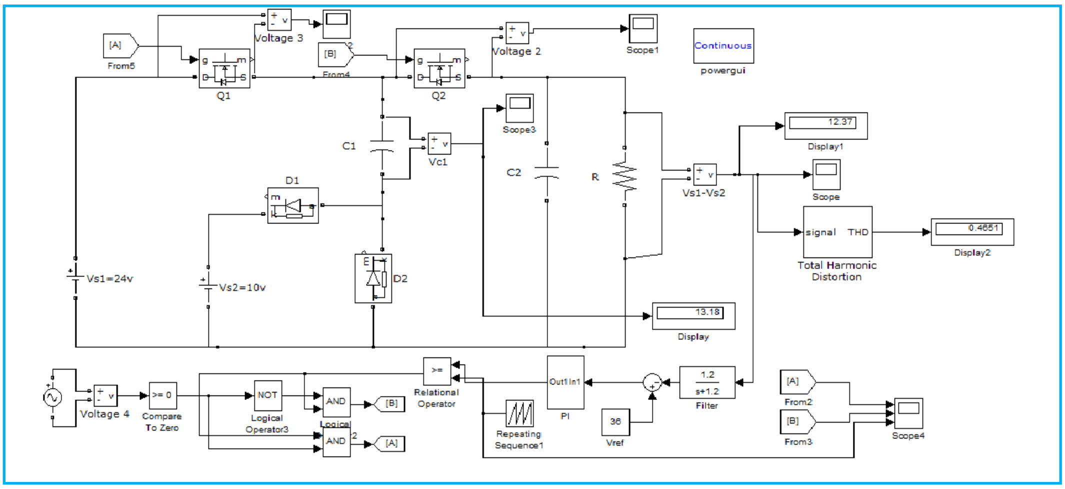
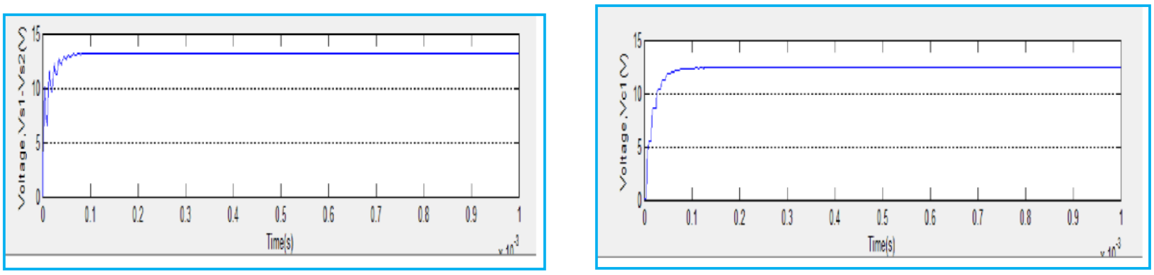


Fig 11: Simulink model of subtraction circuit with feedback



(a) **(b)**

Fig 12: (a) voltage across capacitor (b)output voltage of subtraction circuit

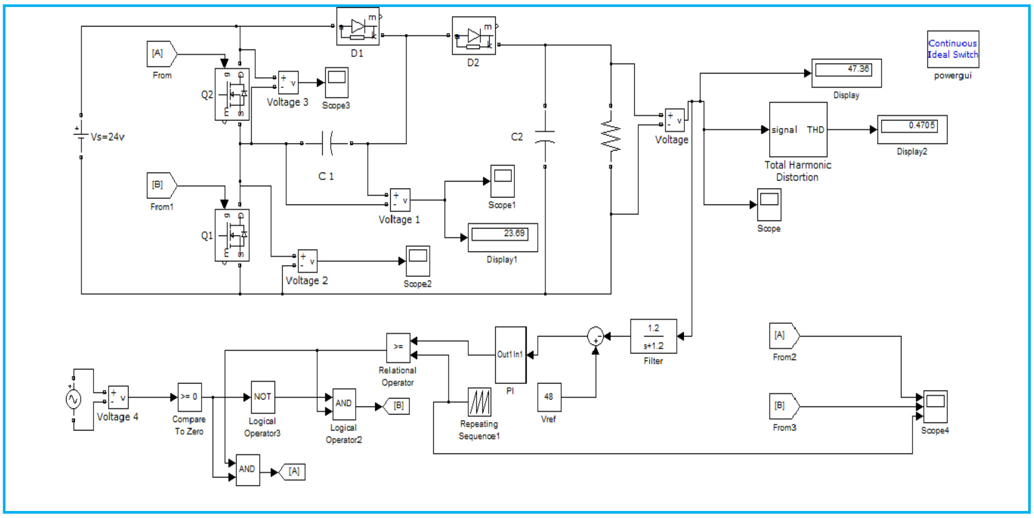
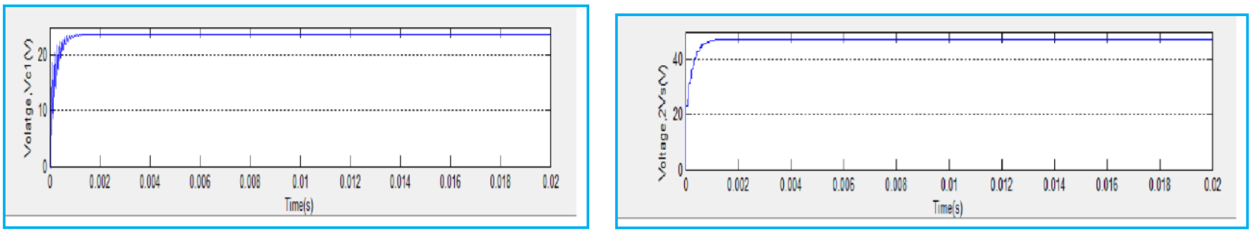


Fig 13: Simulink model of double circuit



(a) **(b)**

Fig 14: (a) voltage across capacitor (b) output voltage of double circuit

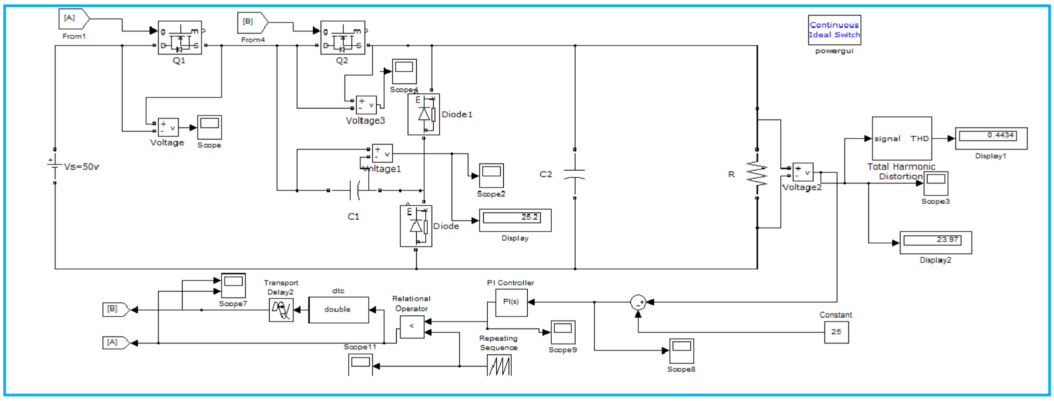
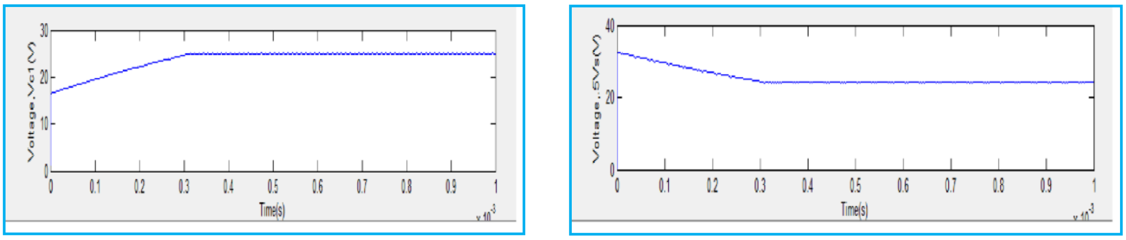


Fig 15: Simulink model of half circuit



(a) **(b)**

Fig 16: (a) voltage across capacitor (b) output voltage of half circuit

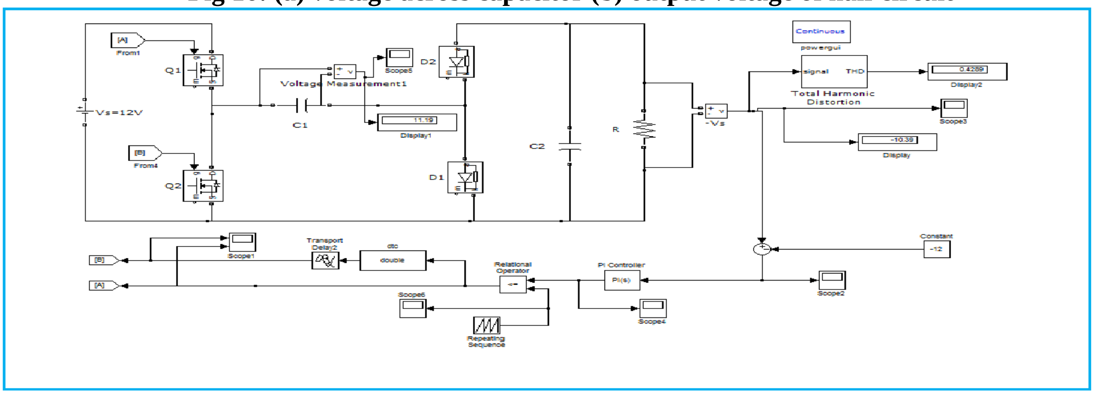
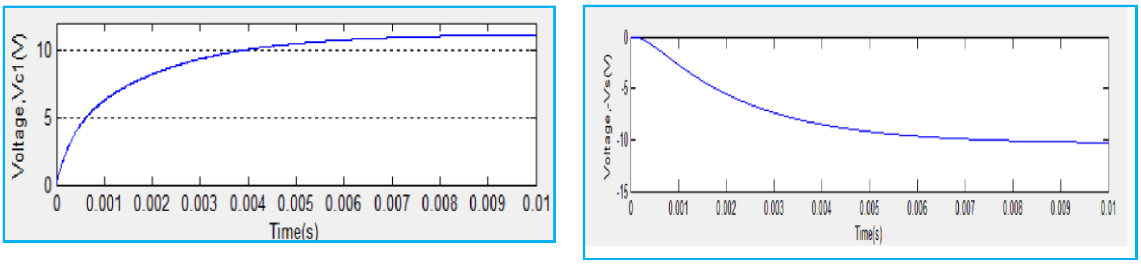


Fig 17: Simulink model of inverting circuit



(a) **(b)**

Fig 18: (a) voltage across capacitor (b) output voltage of inverting circuit

Simulation of each circuit is done in MATLAB. The input voltages for summation, subtraction, double, half and inverting circuit are 24V and 12V, 24V and 10V, 24V, 50V and 12V respectively. The values of capacitors C1 and C2 are 4μF and 2.2μF. The output voltages of summation, subtraction, double, half and inverting circuits are 36V, 14V, 48V, 25V and -12V respectively. The Simulation results are analyzed and the comparison of THD with and without feedback is studied. Table 1 shows the comparison of THD. From the table, it is clear that THD is reduced with the help of feedback circuits

Table 1: Total harmonic distortion with and without feedback

	Without feedback THD (%)	With feedback THD (%)
Summation circuit	76.20	45.93
Subtraction circuit	84.61	46.51
Double circuit	71.79	47.05
Half circuit	51.21	44.34
Inverting circuit	92.08	42.89

V. CONCLUSION

In this paper, a level shifting switched capacitor voltage copier circuit with feedback is introduced. It consists of five circuits. In all these circuits thereare two switches(MOSFET), two diodes, one switching capacitor and one output filter. So the size of circuit is greatly reduced. The proposed system is analyzed and simulation results are presented. Also the % THD for each circuit with and without feedback has been determined and is presented in the paper. It can be observed from table1 that, when feedback is introduced total harmonic distortion is reduced.

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