A switched-capacitor bidirectional dc-dc converter with wide voltage gain range for electric vehicles with hybrid energy sources

ABSTRACT:

A bidirectional dc-dc converter which uses a switched capacitor with a high step-up/step-down voltage gain is proposed for electric vehicles with a hybrid energy source system. The converter can step-up /step-down the voltage having a variable low-voltage side of 40-100 V and high voltage side of 300 V. The proportional Integral controller is used in voltage loop to maintain the constant output voltage of the converter. In this work, a battery fed buck-boost converter and a supercapacitor fed proposed bidirectional dc-dc converter are developed. These hybrid energy sources can be used to develop a 300W prototype.

INTRODUCTION

To address the challenges of fossil fuels as the primary energy source for transport, electric vehicles (EVs) powered by battery systems with low or zero polluting emissions, are increasing in popularity.

Although the developed advancement of batteries can provide higher population performance for EVs, the unlimited charging or discharging current from batteries will result in shorter battery cycle life, as well as reducing the efficiency. The combination of a battery and supercapacitors as a hybrid energy source system (HESS) for EVs is considered as a good way to improve overall vehicle efficiency and battery life.

Supercapacitors have advantages of high-power density, high-cycle life, and very good charge/discharge efficiency. They can also provide a large transient power virtually instantaneously and are, therefore, suitable for meeting sudden EV power changes such as acceleration or meeting an incline

Therefore, a bidirectional dc–dc converter with a wide voltage-gain range is desired for the HESS to connect low-voltage supercapacitors with a high-voltage dc bus.

There are two broad classifications for bi-directional dc-dc converters (BDCs), namely isolated converters and non-isolated converters. The isolated bi-directional converters can achieve a high-voltage gain easily. However, the energy of the transformer leakage inductance may provide high-voltage stress, increase the switching losses, and cause serious electromagnetic interference. Therefore, a non-isolated bi-directional dc-dc converter is often more desirable to reduce the cost, reduce the volume of the converter, and improve the conversion efficiency.

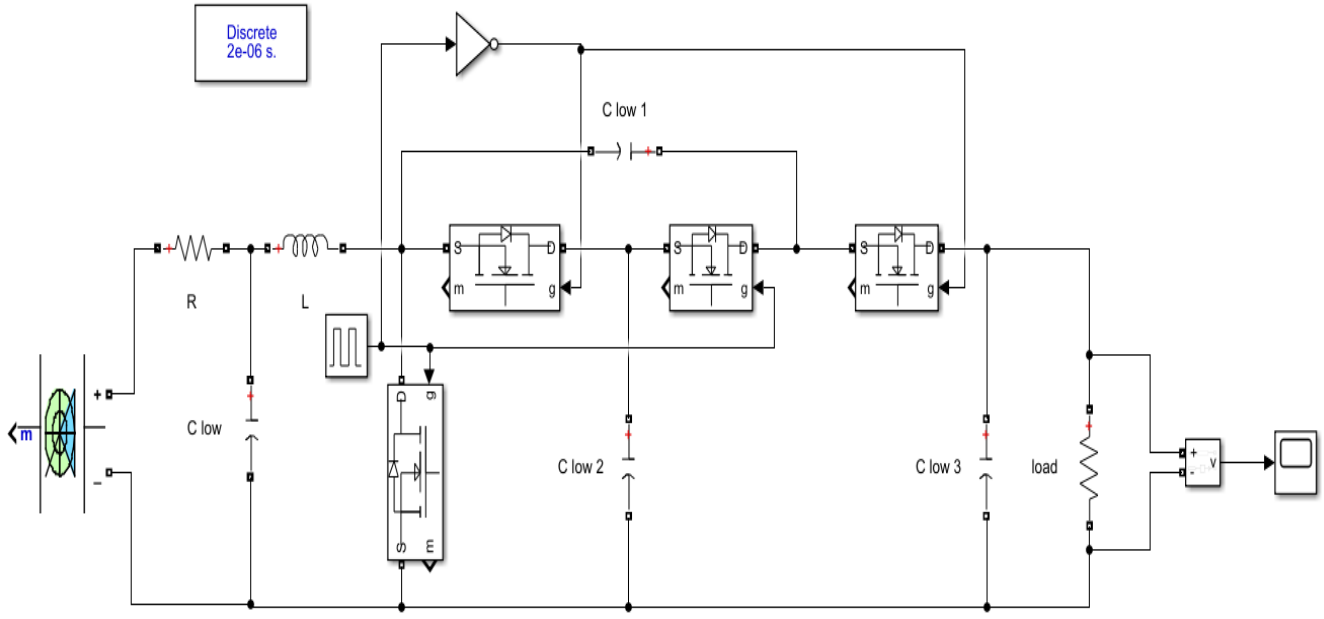
In view of the problems described, a bi-directional dc-dc converter with a switched capacitor is proposed for improving the voltage gain and reducing the voltage stress across the components.

SUPERCAPACITOR FED BIDIRECTIONAL DC-DC CONVERTER

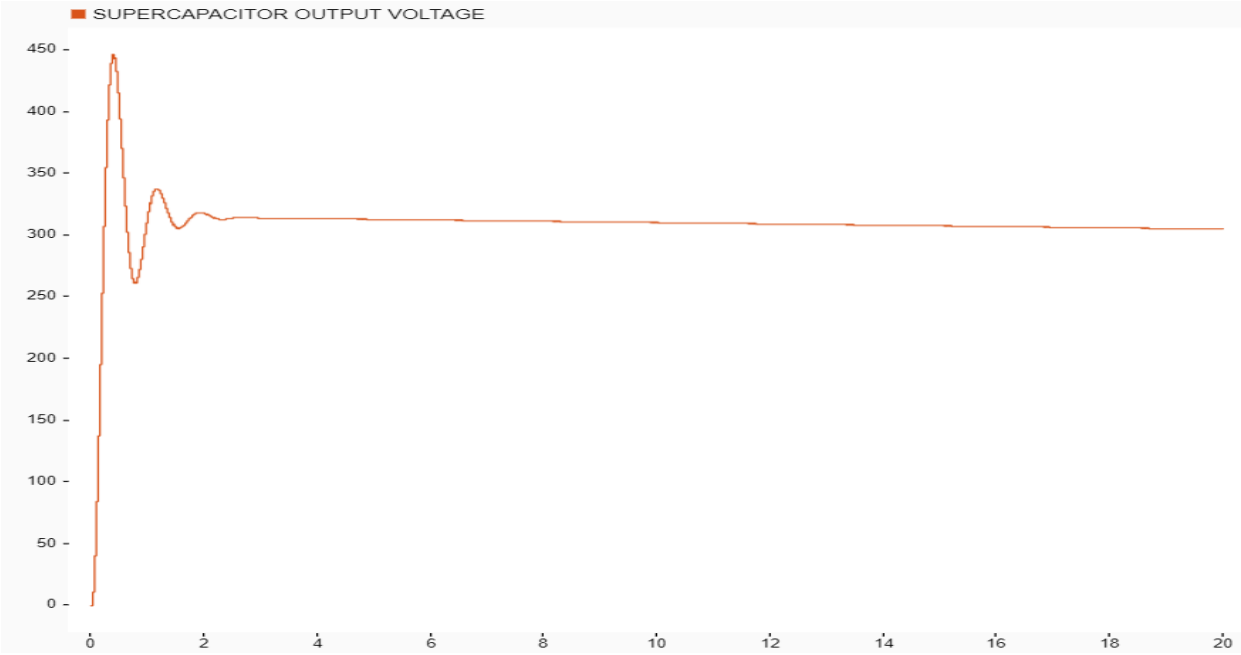
OPEN LOOP CONTROL:

Step-Up Mode:

The energy flows from the low-voltage side to the high-voltage side. The output voltage of the supercapacitor is 40 volts.

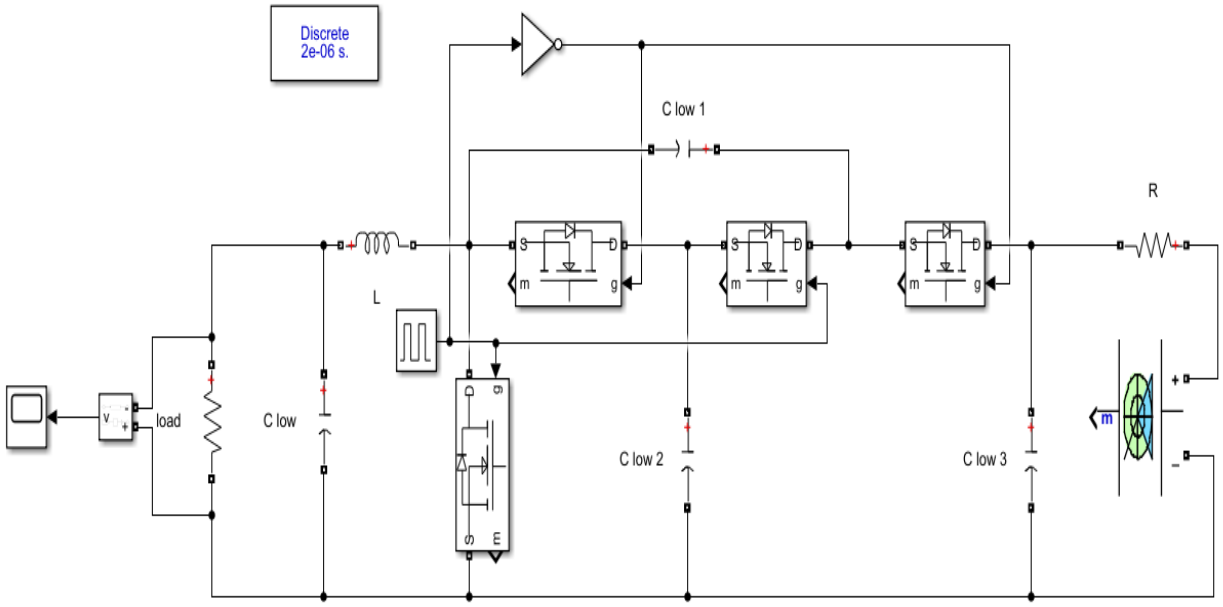


The output of the converter is shown below. The converter step-up the voltage from 40 volts to 300 volts.

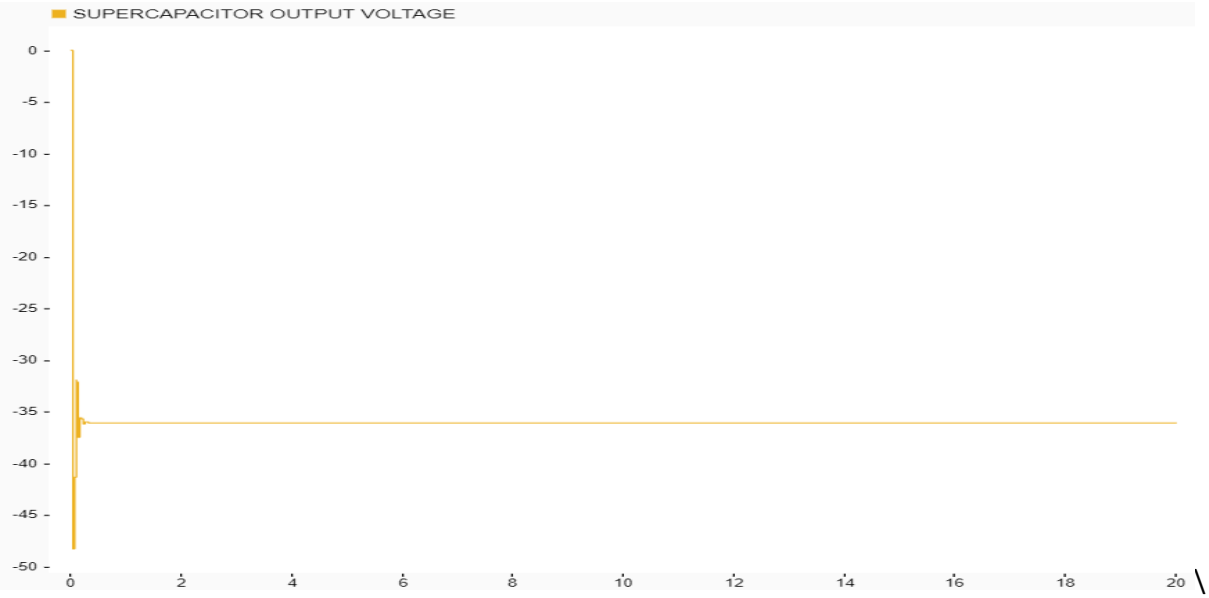


Step-Down Mode:

The energy flows from the high-voltage side to the low-voltage side. The output voltage of the supercapacitor is 300 volts.

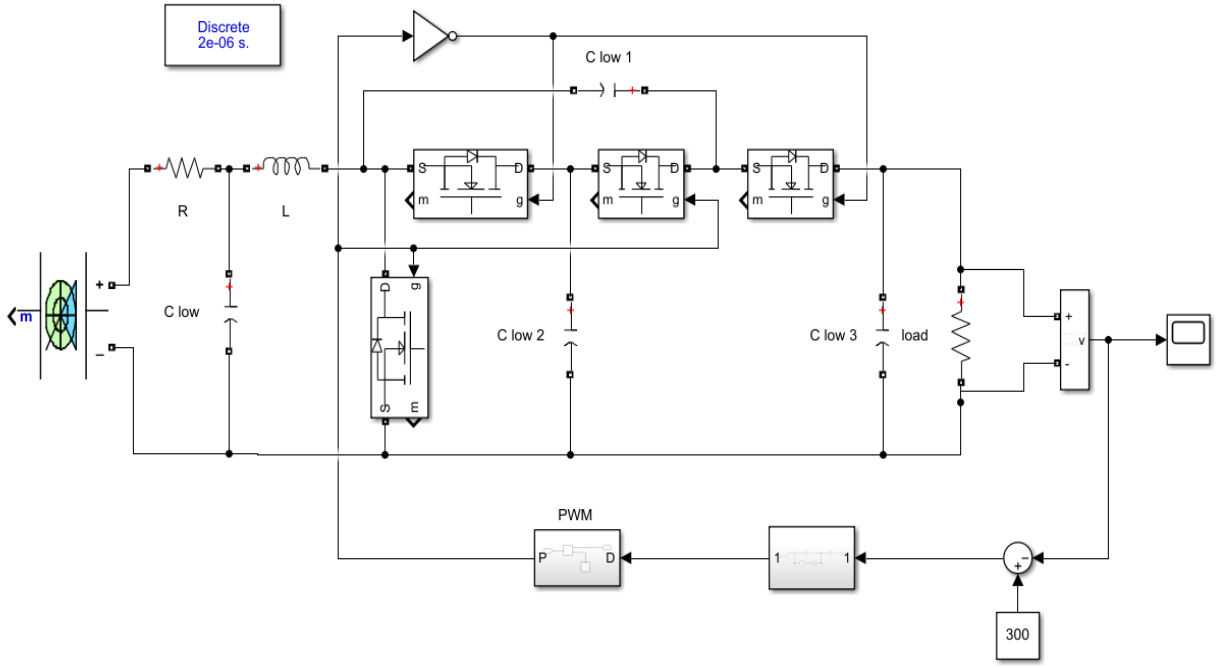


The output of the converter is shown below. The converter step-down the voltage from 300 volts to 40 volts

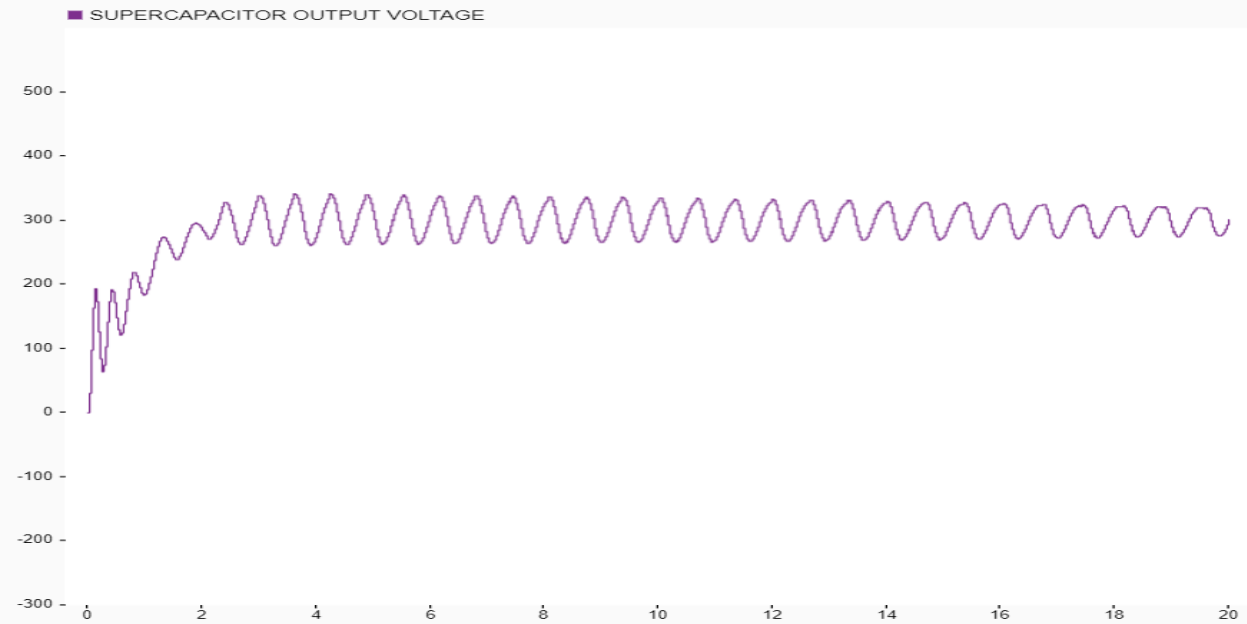


CLOSED LOOP CONTROL:

Closed loop control is used to maintain constant converter output voltage though there is a variation in the input voltage of the converter. A proportional integral controller is sued in the voltage loop. Zeigler-Nichols tuning method is used to find the proportional integral controller parameters.

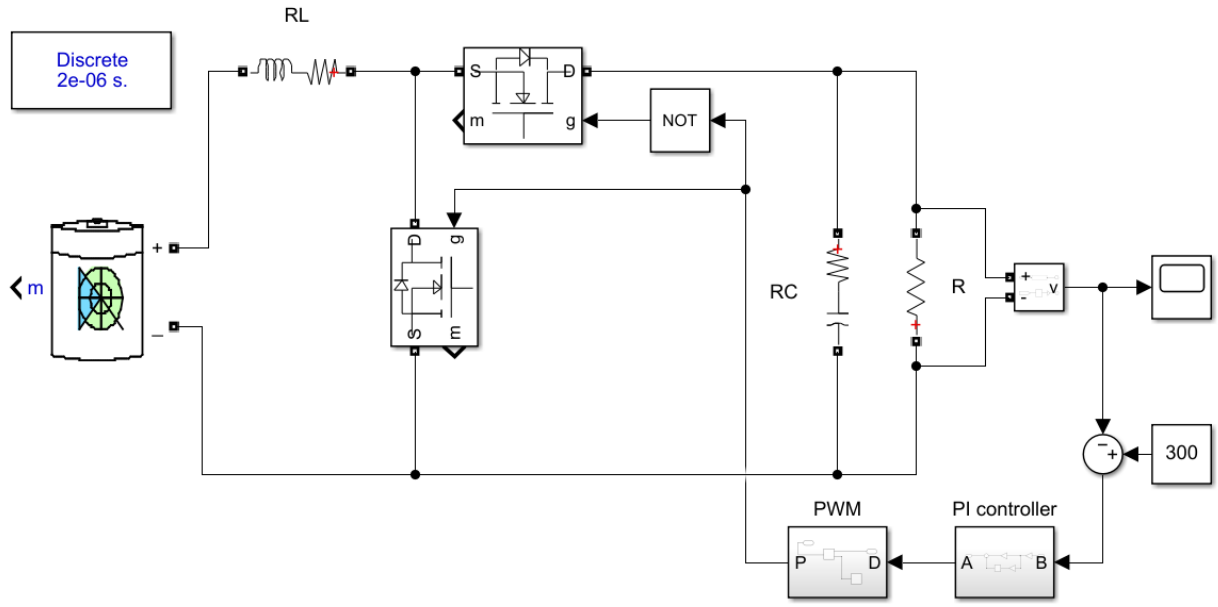


The output voltage of the converter is shown below. With the help of proportional integral controller, the output of te converter voltage is maintained at 300volts.

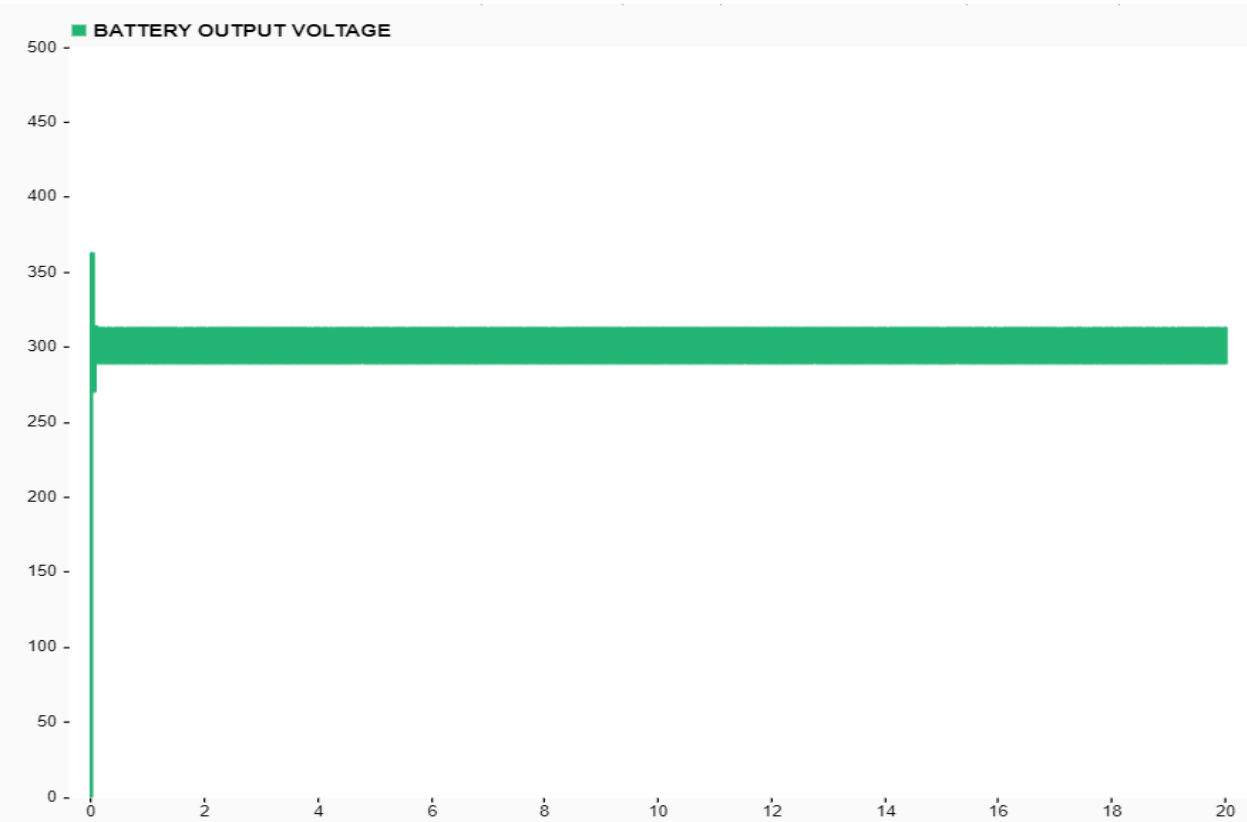


BATTERY FED BUCK BOOST CONVERTER

A battery is used to feed a buck boost converter. The output voltage of the battery is 50 volts. Here, the converter step-up the voltage to 300 volts. To maintain a constant voltage at the output of converter, a proportional integral controller is used in voltage loop. Zeigler-Nichols method is used to compute the proportional integral parameters.



The output voltage of the converter is shown below. The output voltage is maintained constant at 300 volts.



CONCLUSION:

A switched capacitor bidirectional dc-dc converter has been developed. Closed loop control is used in order to reduce the variations in the output voltage with respective to input voltage variation. A 300 W prototype can be developed from the above hybrid energy sources.