CHAPTER 1

INTRODUCTION

1.1 Introduction

Numerous modern applications need variable-voltage Direct Current (DC) sources. This variable source is obtained by transforming a constant voltage Direct Current (DC) source by a DC-DC converter. DC converters are broadly utilized for traction motor control in electric automobiles, marine hoists, trolley cars, mine haulers, and forklift trucks. They give a fast dynamic response, smooth acceleration control, and high efficiency.[Wang, J. et.al 1998].

DC-DC boost converters are designed to operate at high switching frequencies in order to reduce the inductor and capacitor size.[Rashid, M.H, 1993 and Rashid.M.H, 2004]. However, switching the boost converter at high frequency leads to frequent changes in the capacitor voltage and inductor current causing Electro Magnetic Interference (EMI). Hence, DC-DC boost converters are known as practical nonlinear system[Sira-Ramirez, H. 1991, Zabihi. et.al, 2010, Solsona, J. et.al, 2014, Song, A.M. et.al, 2003]

Various methods, such as state space, averaging technique, and transfer function modelling are used to model this highly non-linear system. [Erickson, R.W. and Maksimovic.D, 2007]. Further, closed loop controllers are employed to maintain steady output voltage in the DC-DC boost converter. These controllers are designed to operate at the specific operating point, and they regulate the output voltage for a sudden change in input and output condition.
Luo converters (LCs) are also known as DC-DC converters. It has the following merits in comparison with both the fundamental type and the transformer type converters. The merits are excellent voltage transfer gain, more power density, good efficiency, output voltage, inductor current with small ripples, economical topology in easy formation and suppression of the causes of parasitic elements.

Luo converters are also known as the classical converters. It performs in one quadrant with small power rating (approximately 100W). Further, it is sub-divided into six types namely, fundamental-type, transformer-type, developed-type, type [Massey, R. and Snyder, E. 1977], voltage-lift, super-lift and ultra-lift converters.

The Luo converters (LCs) are divided into three major techniques such as Voltage-Lift Technique (VLT), Super-Lift Technique (SLT), and Ultra-Lift Technique (ULT). VLT is used to lift the output voltage. VLT raises the output voltage transfer gain stage-by-stage in arithmetic series. It can be classified into positive and negative circuits. The positive and negative circuits of VLT can be sub-divided into Elementary, Self-lift, Re-lift and Multiple-lift circuits.

The Elementary circuit structure consists of one diode, two capacitors, two inductors and one power switch. The Self-lift circuit is arranged from the elementary circuit. The re-lift circuit is obtained from the self-lift circuit, and it consists of two diodes, two capacitors, one inductor and one power switch.

A new approach called SLT has been designed, which realizes the output voltage increasing stage-by-stage in geometric progression. The positive and negative circuits of SLT are sub-divided into the main series and additional series circuits. Each series of it can further be sub-divided into elementary Re-lift and Triple-lift circuit.
the re-lift circuit of main series using SLT is derived from the elementary circuit by adding one inductance, three diodes, and two capacitors. The triple lift circuit of main series using SLT is derived from Re-lift circuit by adding one inductance, three diodes, and two capacitors. The additional series using SLT is derived from the main series by adding only the two diodes and two capacitors. Comparison of various LC’s voltage transfer gain is given in table 1.1.

Table 1.1 Comparison of various Luo Converter’s voltage transfer gain

<table>
<thead>
<tr>
<th>DC-DC Converter Topology (Elementary Circuit)</th>
<th>Voltage Transfer Gain</th>
<th>Duty Cycle (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0.2</td>
</tr>
<tr>
<td>Buck</td>
<td>G=Vo/Vin=d</td>
<td>0.2</td>
</tr>
<tr>
<td>Boost</td>
<td>G=Vo/Vin=1/1-d</td>
<td>1.25</td>
</tr>
<tr>
<td>Buck-Boost</td>
<td>G=Vo/Vin=d/1-d</td>
<td>0.25</td>
</tr>
<tr>
<td>Luo-Converter</td>
<td>G=Vo/Vin=n/1-d</td>
<td>0.25</td>
</tr>
<tr>
<td>Super Lift Luo-Converter</td>
<td>G=Vo/Vin=2-d/1-d</td>
<td>2.25</td>
</tr>
</tbody>
</table>

From the above comparison, the super lift luo converter has high voltage transfer gain, increases output voltage stage by stage in geometric progression, increases stability and less voltage ripple.

In this research, an attempt has been made to achieve steady output voltage by splitting the input side capacitor in an elementary additional series positive output super lift converter (SEPOSLC), increasing the output voltage and transfer gain, stage-by-stage in geometric progression. The SEPOSLC gives better voltage regulation against load and line variation by using various controllers like PI, fuzzy logic controller, artificial neural network controller and artificial neural network with sliding mode controller.
1.2 Problem statement

Many researchers analyzed various converters to boost voltage with high gain. When gain of the converter increases complexity of converter also increases. It is noted that among various voltage lift converters and super lift converters produce high gain with less complexity. The Luo converter with split capacitor produces enhanced performance compared to conventional Luo converter. Since super lift converter is the modified form of Luo converter. In this research Split capacitor type elementary additional series positive super lift converter is proposed for analysis.

1.3 Objectives of the study

The main objectives of the study are as follows:

(i) To design a split capacitor type elementary additional series positive output super lift converter to attain high gain with less complexity. Analyse a closed loop control of SESPOLC using the conventional PI controller to attain the required reference voltage in case of variable input voltage.

(ii) To analyse a closed loop control of SESPOLC using various intelligent control techniques are proposed such as a fuzzy logic controller, Artificial neural network controller and artificial neural network with sliding mode controller to minimize the voltage ripple which oscillates output voltage and the settling time of the converter output.

(iii) To elucidate the best method of control by comparing the performance of all controllers in the aspects of voltage ripple and settling time of the converter and to implement hardware of SEPOSCLC using ANN-SMC with a load of three phase inverter fed BLDC motor.
1.4 Methodology of the study

This research proposes control of split capacitor type elementary additional series positive output super lift converter. Various researchers analyzed super lift converters with various intelligent and optimization controllers. In the aspect of the controller, many intelligent and optimization controllers produce better performance compared to PI controller.

![Flowchart of methodology](image)

**Figure 1.1** Flowchart of methodology
Compare to the Fuzzy logic controller and Sliding mode controller the optimization techniques such as GA, PSO, BAT, etc. consumes more processing time due to its execution of multiple iterations to achieve optimum solution in real time implementation. Hence in this research SMC, fuzzy logic controllers are analyzed and compared with artificial neural network controlled converter. Flowchart of methodology of research is shown in Figure 1.1.

1.5 Limitation of the study

Voltage transfer gain of the super lift converter is based on the types of series. The number of components required in the elementary additional series circuit limits voltage transfer gain. For a line voltage variation analysis, variable DC voltage source is applied. It may be renewable energy source such as Photovoltaic, wind or voltage from peltier device or fuel cell. In the case of PV source, converter input voltage is varied with respect to change in irradiance, consequently intelligent proposed controller is applied to regulate the DC output voltage. In the economic aspect in this research variable DC voltage source is used.

1.6 Organization of thesis

This thesis comprises five chapters starting with the introduction to research, and other chapters are as follows:

Chapter 2 depicts a detailed survey of on various types of DC-DC converter, especially Luo and super lift converters, the performance of conventional PI controller and various intelligent controllers on a converter are presented.

Chapter 3 discusses the configuration and working of voltage lift converters of positive output voltage lift converter and split capacitor type elementary additional series positive output super lift converter. It also depicts
closed loop control split capacitor type elementary additional series positive output super lift converter using the PI controller.

Chapter 4 presents a general theory of various intelligent techniques such as a Fuzzy logic controller, Artificial neural network controller and Artificial neural network controller with the Sliding controller and their control to improve the time response specifications and to regulate the DC output voltage of the split capacitor type elementary additional series positive output super lift converter.

Chapter 5 illustrates the implementation of split capacitor type elementary additional series positive output super lift converter with artificial neural network controller with the Sliding controller. It also includes the analysis of converter with a load of inverter fed brushless direct current motor.

Chapter 6 sums up conclusion of this research work and indicate scope for future work.