# A New Model Solid State Transformer (NMSTT)

## Vijayakrishna Satyamsetti

PG Scholar, Department of Electrical Engineering, Jawaharlal Nehru Technological University, Kakinada, Andhra Pradesh, India

## Abstract

A New Model Solid State Transformer (NMSTT) is used as a controllable bidirectional transmission device that can transfer power between asychoronous networks and functionally similar to back-to-back-HVDC . This paper describes the basic concept of a New Model Solid State Transformer (NMSTT). NMSTT is a new technology used for many applications like Traction , Distribution Systems, Power Quality Improvement, Power factor correction etc. A digital simulation model of NMSTT and its control system are developed using MATLAB. In this application field substantial weight and volume reduction can be achieved while providing additional functionality at the same time, also in this paper a survey of recent R&D efforts in this field are presented.

Keywords: Solid State Transformer (NMSTT), single phase model, three phase model, Intelligent universal transformer (IUT).

## 1. Introduction

Revolutionary advances in semiconductor fabrication technology have made it possible significantly improve the voltage and current handling capability and the switching speed of the semiconductor devices used in power systems and its industrial applications. Solid State Transformers (NMSTT) are proposed to reduce the size of the transformer through high operating frequency, and to replace the conventional transformers and perform voltage regulation and power exchange between generation and consumption by electrical conversion. An example of NMSTT is shown in Fig 1.1

At input stage low frequency input is rectified to DC voltage. and the boost converter increases the DC voltage level for power factor correction. During the isolation stage , boosted DC voltage is converterted to high frequency AC voltage by an inverter . The high frequency operation allows the reduction in size and weight of the isolation transformer .The high frequency AC voltage is rectified and converted to the desired AC voltage by an inverter in the output stage.
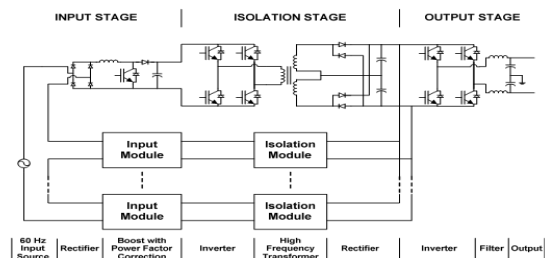


Fig. 1.1. Schematic of solid state transformer.

Recent progress in high power switching devices an electronic transformer is introduced as shown in Fig1.2. Multi-stage power conversion can be reduced by applying an AC/AC converter on

*Corresponding author: sdotvijay@gmail.com

each primary or secondary side of the transformer .desired frequency of voltage can be achieved through AC/AC converter.

## 2. Development of Intelligent Universal Transformer

Electrical Power Research Institute (EPRI) has been researching on Intelligent Universal Transformer(IUT) . It is proposed to replace conventional transformer with state-of-the-art power electronic system. An intelligent and controllable system can provide multiple transformer functions ,such as voltage transformation, voltage regulation ,non-standard customer voltages (DC Or 400 Hz AC), voltage sag correction , power factor control and distribution system status monitoring to facilitate automation .the iut will be a foundation of advanced distribution automation (ADA) that will transform distribution systems into multi functional power exchange systems.
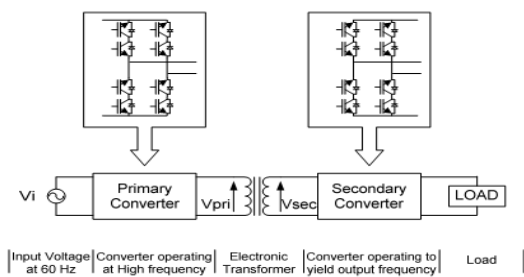


Fig. 1.2. Block diagram of electronic transformer.

The IUT assembly layout is shown as in block diagram 2.1.this layout is designed on the basics of Solid State Transformer (NMSTT) as discussed earlier
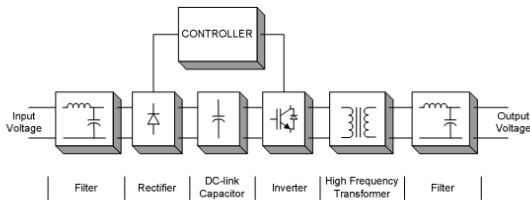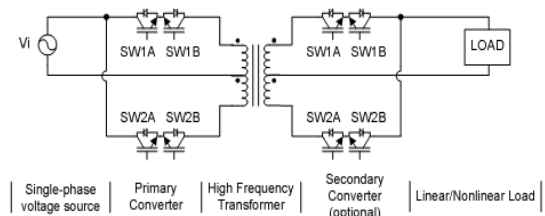


Fig. 2.1. EPRI intelligent universal transformer (IUT) layout.

## 2.2 Development of Single Phase Solid State Transformer

The development of NMSTT is shown in Fig 2.2.Single phase ac/ac converters are applied to preimary and secondary windings of a transformers.
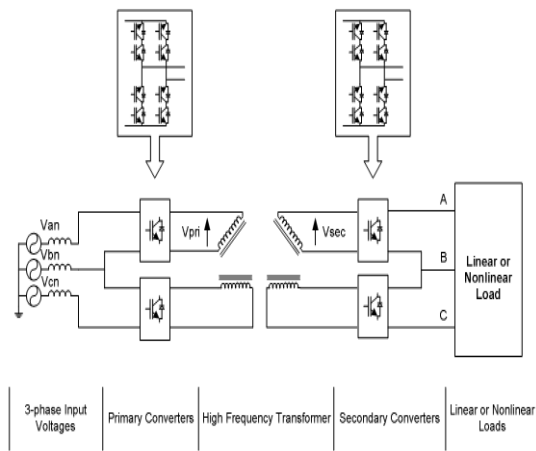
Fig 2.2(a) shows the development Of Solid State Transformer system which includes Ac/Ac converters with bidirectional switches connecting in half bridge arrangement. Fig 2.2(b) shows the development of solid state transformer system which includes AC/AC converters with bidirectional switches connecting in full bridge arrangement.the development in Table 2.1(a) requires the least number of bidirectional

switches, but large size of transformer then the development as shown in Fig 2.1(b).



(a) Half-bridge single phase electronic transformer system.

Fig. 2.2. Topologies of single phase electronic transformer system.



(b) Full-bridge open delta three-phase electronic transformer system.

The system consists of a high frequency transformer with open delta connection .single phase AC/AC converters are selected to generate high frequency voltages on transformer primary windings . on the transformer secondary side ,single phase AC/AC converter restore the voltages with input frequency .with this development the NMSTT system can produce sinusoidal output voltages with no additional filters are required.
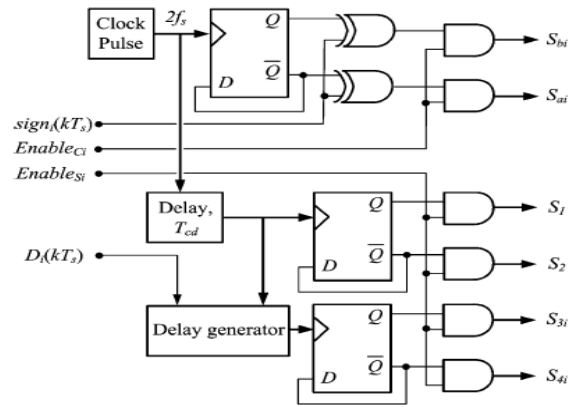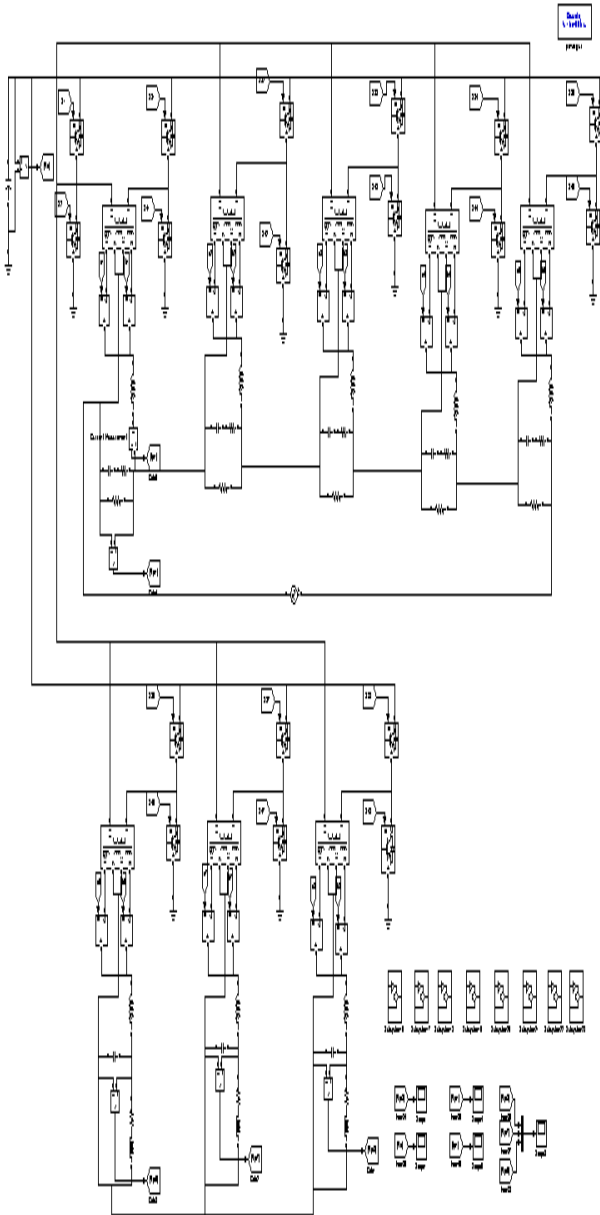
Number of semiconductor switches used in each development is shown table 2.1

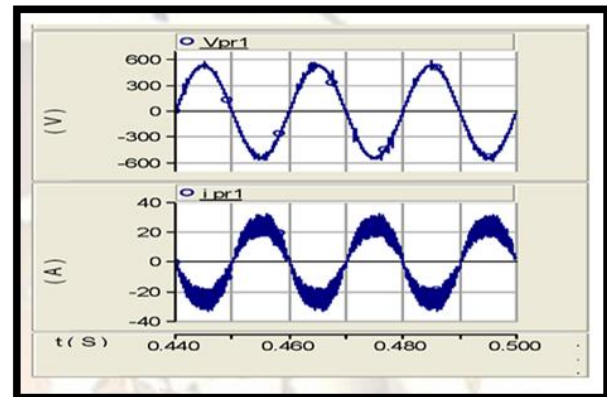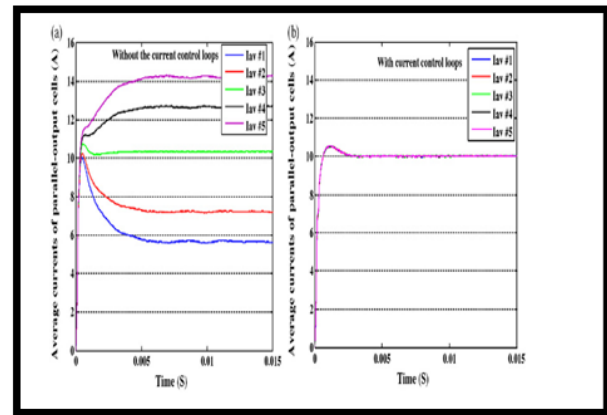Table 2.1. Number of semiconductor switches used in electronic transformer system.

| Electronic Transformer System Topology | Number of switches |
|---|---|
| Half-bridge single phase electronic transformer system | 8 |
| Full-bridge single phase electronic transformer system | 16 |
| Half-bridge open delta three-phase electronic transformer system | 16 |
| Full-bridge open delta three-phase electronic transformer system | 32 |

The control circuit is responsible for providing pulse gate of dc link switches and the cycloconverter. The input data address consists of four lines. The first line is polarity of output voltage
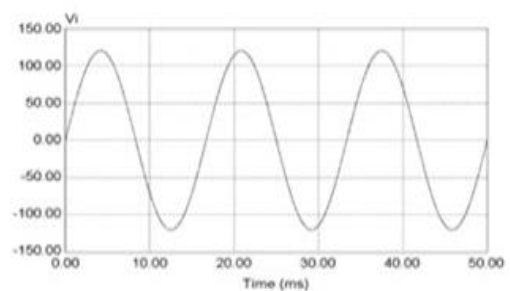
signi. The second line is switch-enabled of cycloconverter (EnableCi ). The third line is switch-enabled of dc link (EnableSi ). The fourth line provides the duty cycle data of the ith port. The enabled lines are provided by the startup and protection circuits
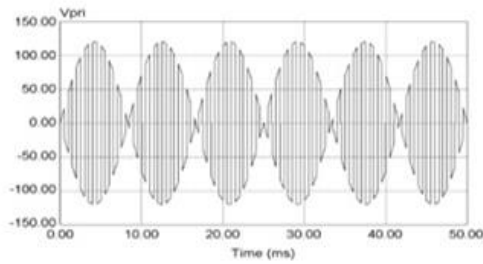


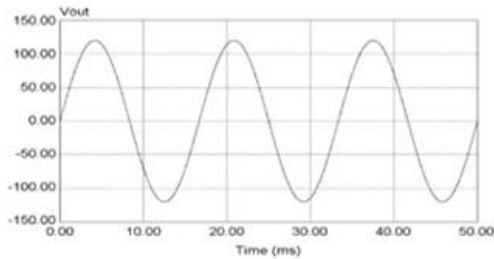## Control Circuit

## Results
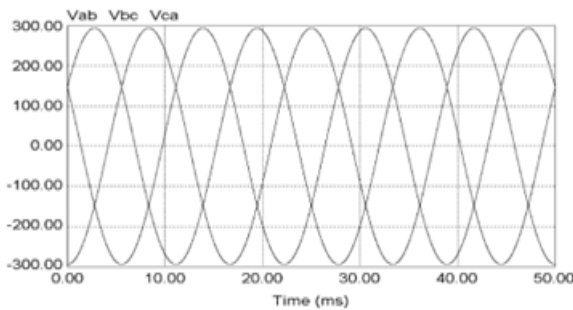






(a) Input voltage $V_i$ (120 V 60 Hz).

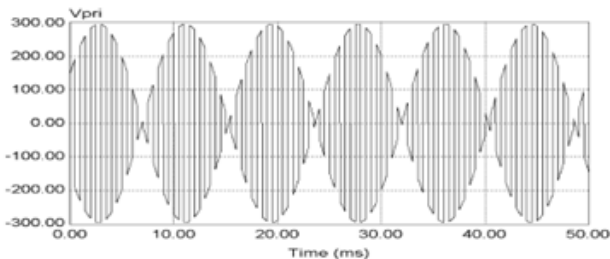(b) Transformer primary voltage $V_{pri}$ (1000 Hz).



(c) Output voltage $V_{out}$ (120 V 60 Hz).

Single phase electronic transformer system voltages.



(a) Three-phase input line voltages (208 V 60 Hz).



(b) Primary voltage of the transformer (1000 Hz).

In this section simulation results of the proposed approach are discussed.

## Conclusion

In this dissertation, Design of Solid State Transformer system has been presented. The concept of electronic transformer operating at higher frequency has been shown to effectively achieve size, weight, and volume reduction of transformer.

## References

Basu, K.; Gupta, R.K.; Nath, S.; Castelino, G.F.; Mohapatra, K.K.; Mohan, N.; , "Research in matrix-converter based three- phase power-electronic transformers," Power Electronics Conference (IPEC), 2010 International , vol., no., pp.27992803, 21-24 June 2010

C.Wm.T.McLyman: "Transformer and inductor design handbook", Marcel Dekker Inc, 2004.

Dražen Duji ć, Frederick Kieferndorf, and Francisco Canales, Power Electronic Transformer Technology for Traction Applications – An Overview

Frank R.Goodman,Jr., The EPRI Intelligent Universal Transformer (IUT), Workshop on

H. Iman-Eini and S. Farhangi, "Analysis and design of power electronic transformer for medium voltage levels," in Proc. IEEE Power Electron. Spec. Conf., Jun. 2006, pp. 1–5.

H. Liu, C. Mao, D. Wang, "Optimal regulatobased control of electronic power transformer for distribution systems," Electric Powe Systems Research, vol. 79, pp. 863-870, 2009.

International Standardization for Distributed Energy Resources, Vol.8, NO.10, 2009, pp. 144 28.

M.Claessens, D.Dujic, F.Canales, J.K. Steinke, P.Stefanutti, C.Vetterli "Traction transformation – A power electronic traction transformer (PETT)", ABB Review, 1/12, 2012, pp. 11-17.