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A New Model Solid State Transformer (NMSST)

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ABSTRACT:

A New Model Solid State Transformer (NMSST) is used as a controllable bidirectional transmission device that can transfer power between asynchoronous networks and functionally similar to back-to-back-HVDC . This paper describes the basic concept of a New Model Solid State Transformer (NMSST). NMSST is a new technology used for many applications like Traction , Distribution Systems, Power Quality Improvement, Power factor correction etc. A digital simulation model of NMSST 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 (NMSST), single phase model, three phase model , Intelligent universal transformer (IUT).*

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 (NMSST) 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 NMSST 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 convertered 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.

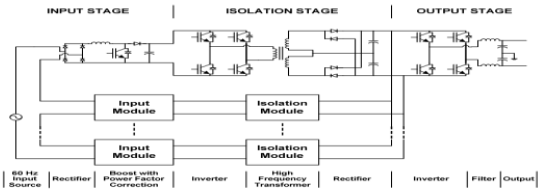


Fig. 1.1. Schematic of solid state transformer.

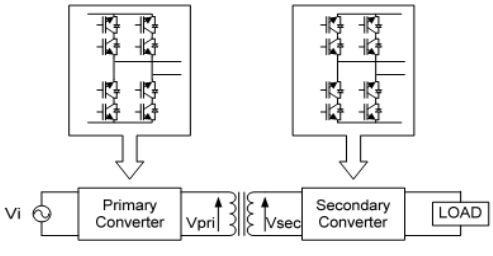


Fig. 1.2. Block diagram of electronic transformer.

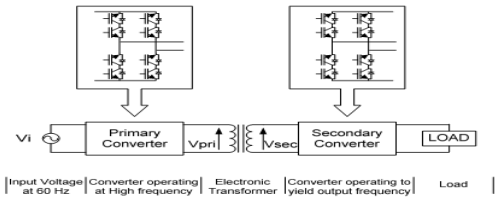


Fig. 1.2. Block diagram of electronic transformer.

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 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.

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

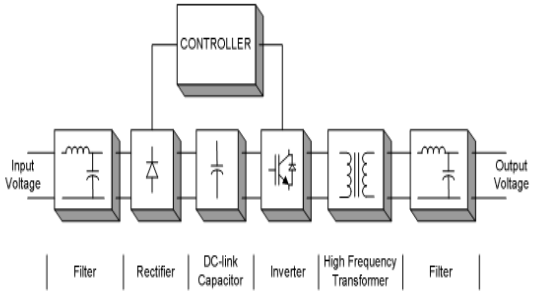
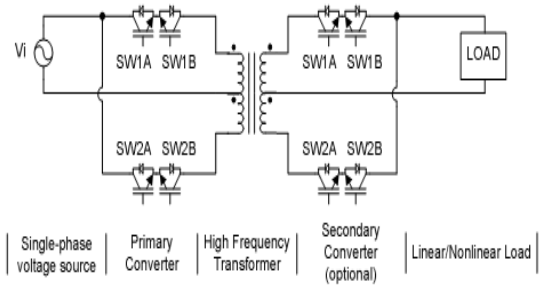


Fig. 2.1. EPRI intelligent universal transformer (IUT) layout.

2.2 DEVELOPMENT OF SINGLE PHASE SOLID STATE TRANSFORMER

The development of NMSST is shown in Fig 2.2.Single phase ac/ac converters are applied to preimary and secondary windings of a transformers.

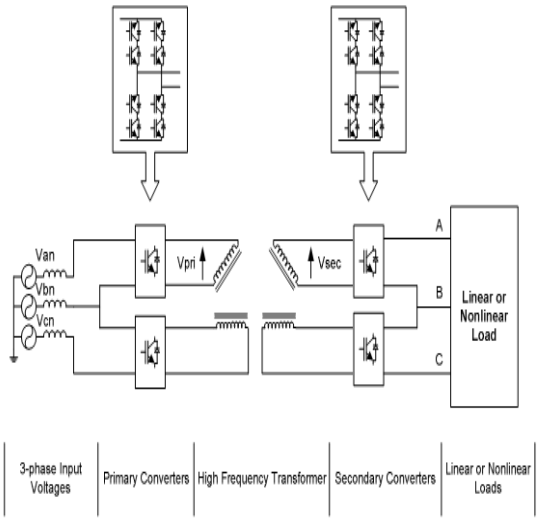


(a) Half-bridge single phase electronic transformer system.

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

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).



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

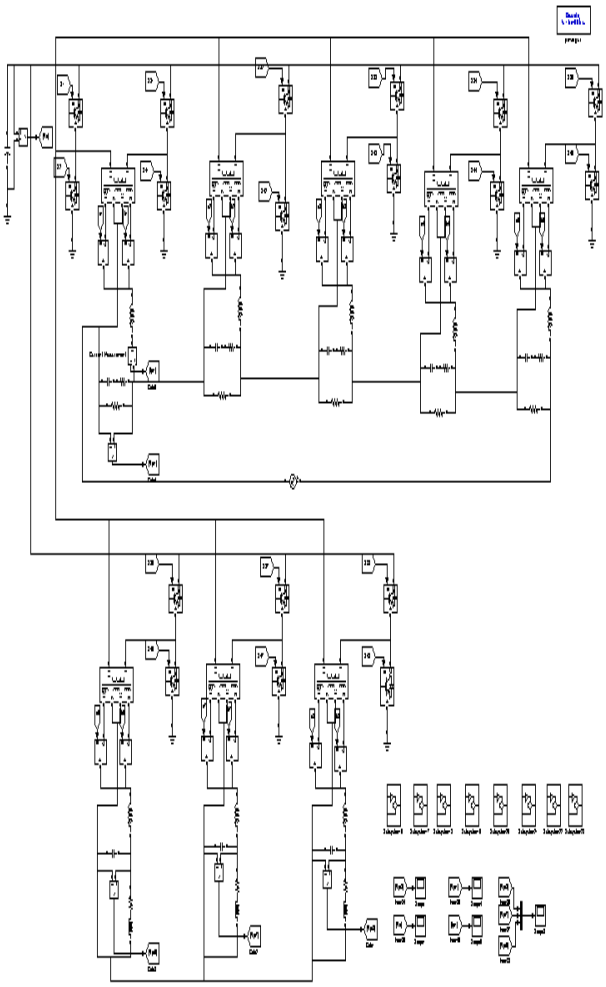
The system consists of a high frequency transformer with open delta connection .single phase AC/AC converters are selected to generate high frequency voltages on transformer primary windings . on the transformer secondary side ,single phase AC/AC converter restore the voltages with input frequency .with this development the NMSST 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

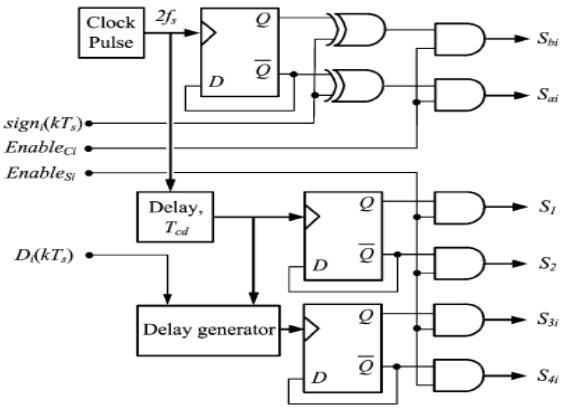
Table 2.1. Number of semiconductor switches used in electronic transformer system.

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

Results and discussion



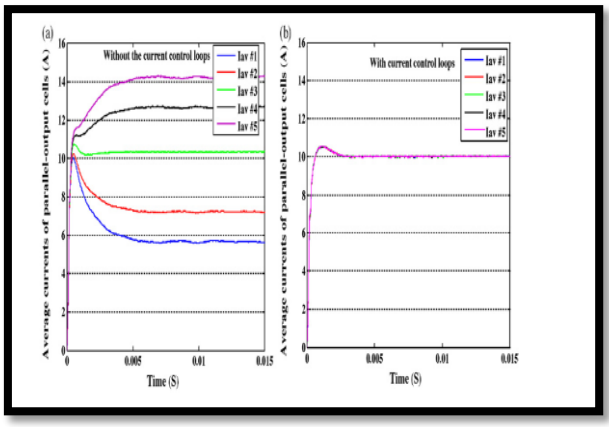
CONTROL CIRCUIT :

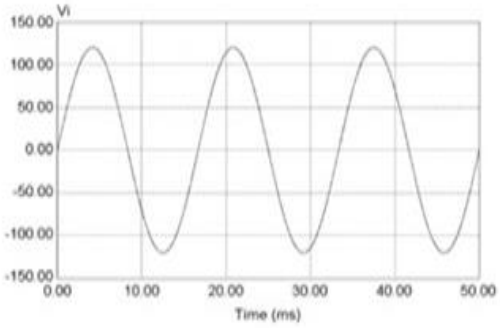


The control circuit is responsible for providing pulse gate of dc

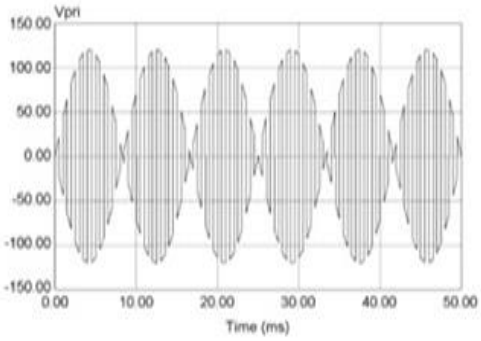
link switches and the cycloconverter. The input data address consists of four lines. The first line is polarity of output voltage signi. The second line is switch-enabled of cycloconverter (EnableCi). The third line is switch-enabled of dc link (EnableSi). The fourth line provides the duty cycle data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

RESULTS :

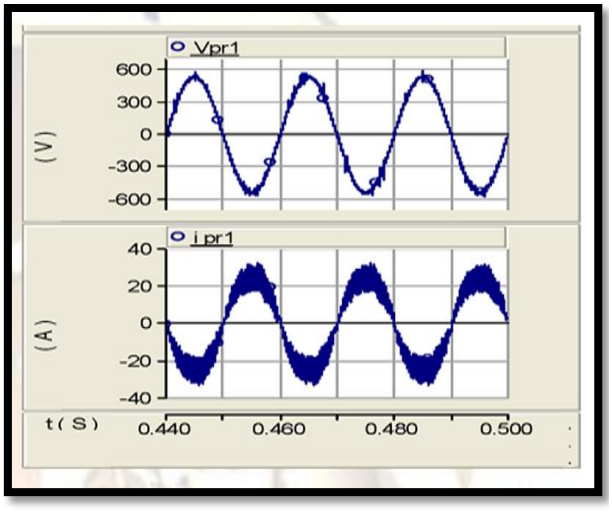


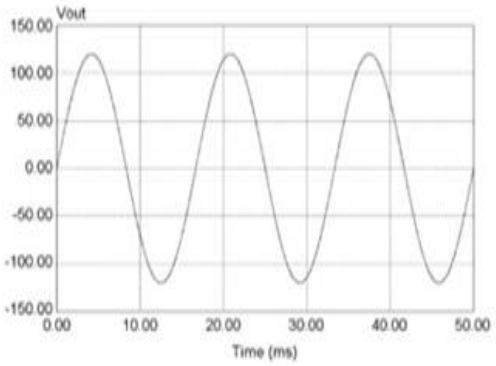


(a) Input voltage V_i (120 V 60 Hz).



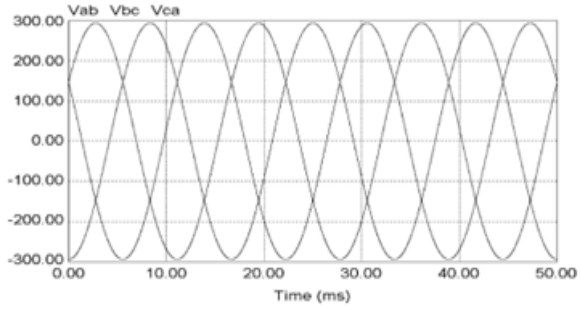
(b) Transformer primary voltage V_{pri} (1000 Hz).



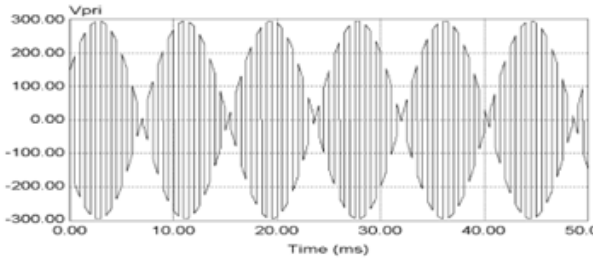


(c) Output voltage V'_{out} (120 V 60 Hz).

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 have been presented. The concept of electronic transformer operating at higher frequency has been shown to effectively achieve size, weight, and volume reduction of transformer.

The single phase and three- phase electronic transformer systems have been explained and analyzed. The various application of Solid State Transformer also mentioned with effective use of Solid State Transformer Leads to replacement of utility conventional transformers .

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