DESIGN, PROTOTYPING AND IMPLEMENTATION OF HIGH FREQUENCY TRANSFORMER MULTIPLE CONVERTERS IN SMART MICRO GRID APPLICATION

Shailaja Patil[1], Rakesh M N[2]
[1]PG Student [2]Assistant. Prof. RNSIT

Abstract

The electrical Buses have been replaced by High Frequency magnetic links due to the advancements in magnetic material characteristic. There can be reduction in the no. of stages in renewable energy system by using Multi-winding Transformer (MWTs) as magnetic links. Some of the advantages of using Multi winding transformer are the Isolation between primary and secondary, ability of power flow bidirectionally and capacity of power transfer simultaneously. Due to the complex structure and cross coupling effects design of MWT's is relatively complex. This paper presents Design of the transformer, Prototype used for the transformer and their characterization for Micro Grid application. The prototyping includes the type of materials and insulation used for High Frequency transformer. Experimental tests like transformer tests are conducted using capacitive load and inductive load to understand the transformer behavior. By using HF inverters it is possible to obtain proper conversion from DC to AC and to achieve a sinusoidal wave of required voltage at the output stage. The circuit is simulated in MATLAB simulink with different load conditions using High Frequency transformer.

Keywords: High frequency transformer, MWT's, Inverter, Battery

I INTRODUCTION

The power port of the MPC can be input, output, or bidirectional. Based on the direction of flow of power there are four types of MPC topologies. Multi-input, multi-output, hybrid port and multi-port bidirectional topologies. In a Multi-input topology it is possible to interface multiple sources with a common load.

They are advantageous for stand-alone renewable power system to form a connection between renewable source, a storage battery, and a load. DC micro-grids and/or electric vehicles require interfacing of multiple storages in which a bidirectional multiport converter is been used.

Research on the High frequency transformers mainly deals with the characterization and modeling and there is no detailed research on design methods. This paper deals with the complete description of design, prototyping and experimental tests conducted on the transformer.

In order to interface various sources of power and storage devices the multiport DC-DC converter is used. The power flow is managed by the multiport DC-DC converter and also it regulates the system voltage.

By understanding redundancy in power processing there can be reduction in no. of stages in the renewable system that uses multiple converters. It can be seen that there is a possibility of sharing system resources and to eliminate redundancy. Therefore there is a possibility in the improvement of overall system efficiency by removing redundant power stages with their associated losses.

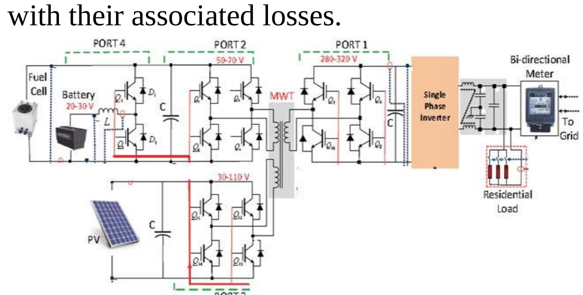

Fig.1. Structure of proposed multi-active bridge phase shift converter.

II. MULTI-WINDING TRANSFORMER AS A MAGNETIC LINK

To integrate the renewable energies effectively Multi winding transformers have been used as the common magnetic links in multiactive phase shift converters [1]-[4]. The system includes four ports as shown in the Fig.1.

High-Frequency ac square wave is produced by the H-bridges by the DC buses linked to DC sources. Ports two, three are controlled by using Phase shift Technique. The phase shift technique is applied by selecting port one as reference port. Now port two and three are shifted for lagging or leading phase angles to receive or send power to port one.

To obtain maximum power point tracking of PV panel Duty cycle is also applied. Port two and three are inverters for DC to AC conversion. Port four consist of two boost converters and is fed from a 12v battery. Port two and three are also fed from a 12v battery. Port one here is a cyclo converter. The ouput of cyclo converter is given to the residential load. The MWT used helps in Bi-directional flow of power from source to grid and from grid to source.

For combining renewable energies by means of magnetic flux, the High frequency transformers (MWT) may provide a common magnetic link. Therefore it possible to integrate the sources using different voltage levels of different turn ratios with their application in multi-active bridge phase shift converter [5]-[8].

III. PROTOTYING OF THE TRANSFORMER

For a Residential or local Micro-grid application a transformer prototype is implemented. There are several strands used in the wire of High frequency transformer. Each strand has some effects. The effects are given below:

1. Whole wire can have skin effect.
2. Each wire can have skin effect.
3. Internal fields present in the wire causes proximity effect
4. External fields from other wires cause proximity effects.

Litz wire is been used to greatly reduce skin and proximity effect. Normally, the wire is circular shape but special compacted. Therefore, each turn consists of multiple Litz wires, stacked axially. Insulation material is chosen as Epoxy in the dry type transformer. Epoxy generally has a maximum dielectric strength and good heat conductivity compared to transformer oil and is well suited for dielectric applications.

INSULATING MATERILAS PROPERTIES
Table.1

Dielectric Strength, V/mil	600
Dielectric constant	3.9
Thermal Condictivity, W/(mK)	0.65

IV. DESIGN OF MULTI- WINDING TRANSFORMER

Due to the structural complexity and also cross coupling effects design of MWTs for certain value of inductances using the classical methods of transformer design is not accurate. The flow chart includes various steps involved in design of transformer. Details of design of transformer are out of scope of this paper and here we are concentrating more on prototype and experimental tests performed.

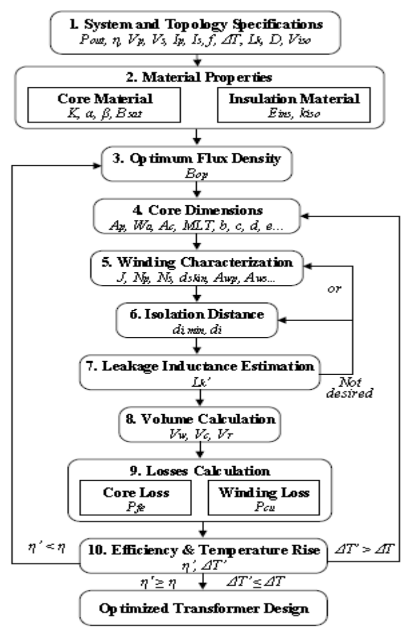

Fig.2 Flow Chart of High Frequency Transformer

V. BLOCK DIAGRAM REPRESENTATION

A 12v battery and solar panel are used as energy sources and are given as input to the boost converters as shown in the block diagram. The output of the two boost converters give 60v each and it act as input to High frequency transformer. The output of the transformer acts as input to the cycloconverter (Inveter and rectifier), which is used to switch High frequency to operating frequency (50Hz). The output is a pure sinusoidal wave of 230v (rms).

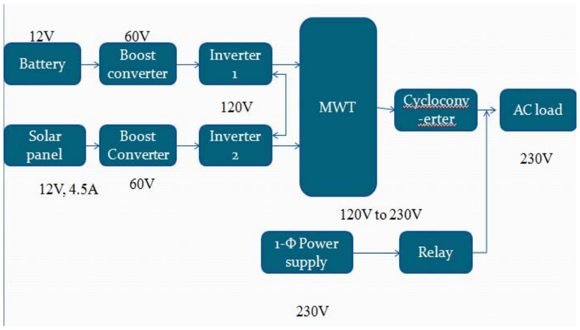

Fig. 3 Block Diagram Representation

VI. TRANSFORMER TEST RESULTS

Various transformer test have been conducted with different load to understand the transformer parameters. The various tests conducted are:

1. With capacitive load

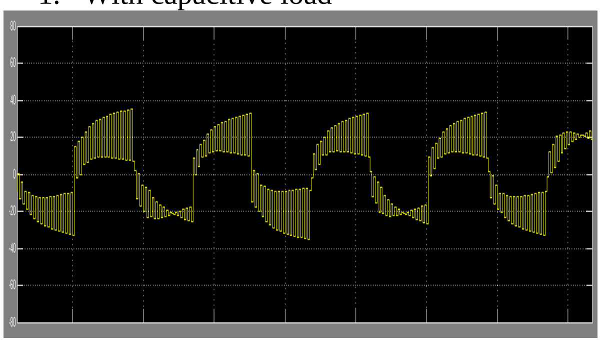

Fig. 4 Voltage vs Time

2. For short circuit condition

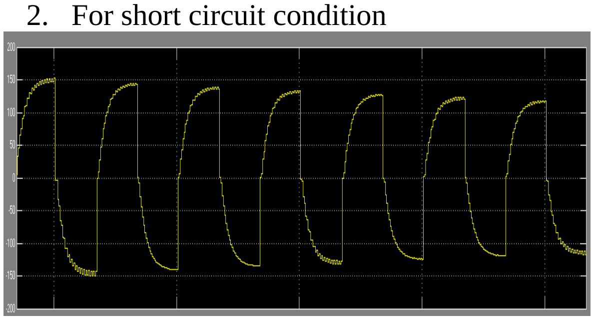

Fig.5 Vottage vs Time

SIMULATION RESULTS FOR INVERTER OUTPUT AND TOTAL OUTPUT

Inverter output at input side – 60V

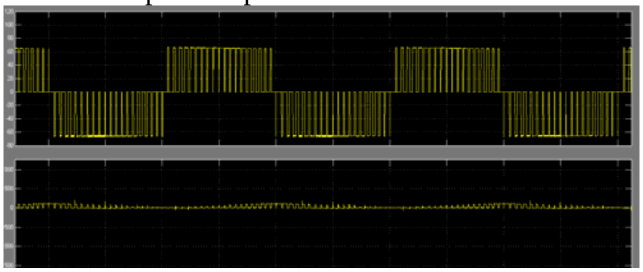

Fig.6 Inverter output -60V

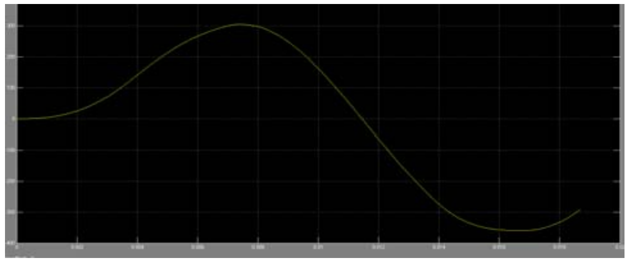

Fig.7 Total Output of the system-230V (rms)

VII. CONCLUSION

We have achieved required isolation between primary and secondary sides by implementing High frequency magnetic link concept. The voltage conversion typically necessary for the operation of the system is achieved. High efficiency upto 96%. Switching of the frequency from Medium to Low using Cycloconverter is achieved. A better understanding of transformer is done by conducting tests on various load conditions. There is also reduction in the THD (total harmonic distortion)

VIII. REFERENCES

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