Multi Phasing Half Wave Converter Using Voltage Doubler For High Voltage Test Equipments

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ABSTRACT: This paper presents a Comparative analysis of Multiphasing Half wave Converter using Voltage Doubler for high voltage test equipments. High voltage test equipments verifies the insulation of products or components ,protect the operator from electric shocks .Multiphasing is used to reduce the size of filter components ,further it reduces output side ripple .The use of voltage doubler provides higher output voltage .The proposed converter is simulated in open loop and closed loop. The simulation results are verified experimentally.

INDEX: Hipot test, Multiphasing, Voltage Doubbler , Half wave Converter , Coupled Inductors and Switched Capacitors , Fuzzy PID Controller.

I INTRODUCTION

Hipot test (HV test) has the highest priority among all of the electrical safety tests. Hipot test deals with dielectric strength, the requirements of all national standards (e.g. VDE and UL) and international standards (e.g. EN and IEC). The often used term insulation test or insulation measurement is used to measure direct voltage. The hipot test is done in both direct and alternating current, it results in leakage current, flowing between live parts and the metallic casing. Devices used for protection class I is metalcasing and metal contour is used for protection class II. Devices of protection class I always come with a metal casing, whereas the casing of the devices of protection class II must be replaced by a metallic contour during the test, the Hipot test gives the information about the a geometric distance measurement in the DUT (Device Under Test),when the DUT withstands a certain voltage without flashover, an appropriate minimum distance between the metal casing and electrical components in the device is ensured.

1.1Requirements for the Hipot Tester

Some national and international standards specify a rating of greater than 500 VA for hipot testers. It requires a permanent current of 100 mA with a short circuit current of 200 mA is required. Hipot tester generates reactive currents and it uses capacitances for their design. Due to these reactive currents, the testers generate a voltage ramp. This means that the voltage is not abruptly, but smoothly ramped up from zero to the desired value. All hipot testers of SPS electronic are fully electronic with analog or digital technology; multiphasing half wave converter using voltage doubler is proposed to generate high voltage ramps.

1.2 Multiphasing Half Wave Converters

The proposed converter is the integration of multiphasing half wave converter and voltage doubler.

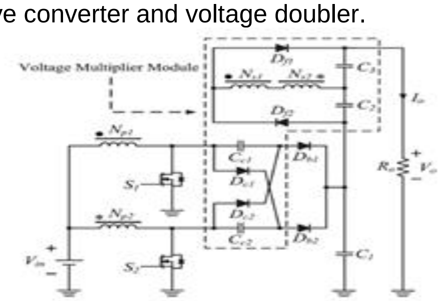

Fig.1.1: Circuit diagram of Multiphasing half wave converter.

The Multiphasing Half Wave Converter consists of two diodes (D_{b1},D_{b2}) and voltage multiplier circuit consists of four diodes D_{f1},D_{f2}, D_{c1},D_{c2} with four capacitors C_{c1},C_{c2}, C_2,C_3. For generating high voltage Ramps multiphasing half wave converter is used.

II SIMULATION RESULTS

The Multiphasing Half Wave Converter is simulated using MATLAB with LCC,LCL,LLC,CCL,CLC,CLL filters in open loop circuit. In closed loop circuit PI, FUZZY PID and SMC controller is used to get stable output voltage.

Table 2.1 SOFTWARE PARAMETERS

PARAMETER	RATINGS
MOSFET	IRF840
DIODE	IN4007
L	1Mh
R	1KΩ
C_{c1}=C_{c2}	1µF
INPUT	40V
L_{k1}= l_{k2}	10mH
C_1=C_2=C_3	220µF

2.1 OPEN LOOP SYSTEM

2.1.1 Multiphasing Half Wave Converter with LCL Filter

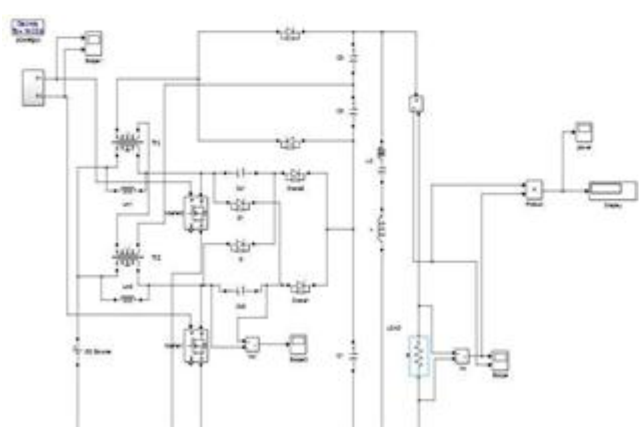

Fig.2.1: Circuit diagram of Multiphasing half wave converter with LCL filter

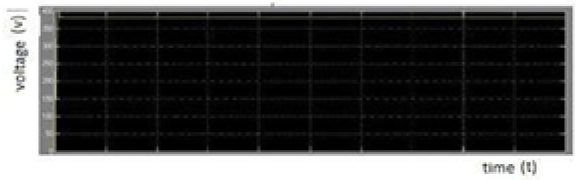

Fig.2.2: Output voltage

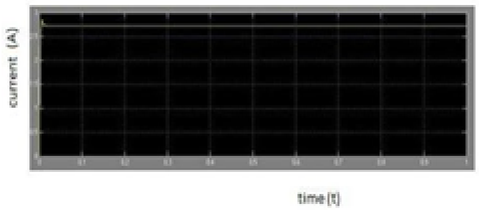

Fig.2.3: Output current

2.1.2 Multiphasing half wave converter with LLC Filter

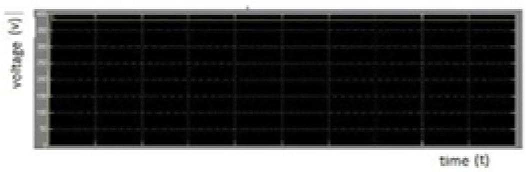

Fig.2.5: Output voltage

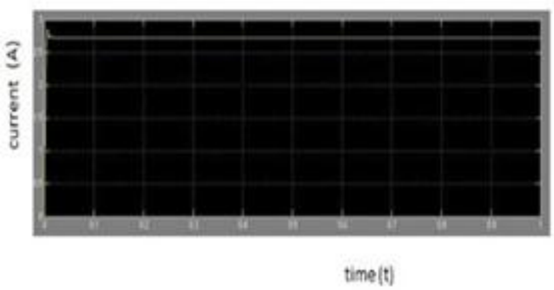

Fig.2.6: Output current

2.1.3 Multiphasing half wave converter with LCC Filter

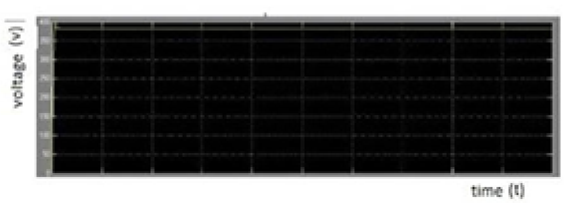

Fig.2.8: Output voltage

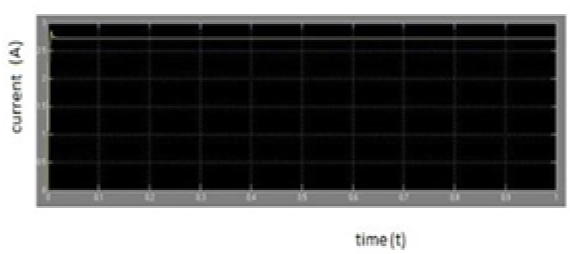

Fig. 2.9: Output current

2.1.4 Multiphasing half wave converter with CLL Filter

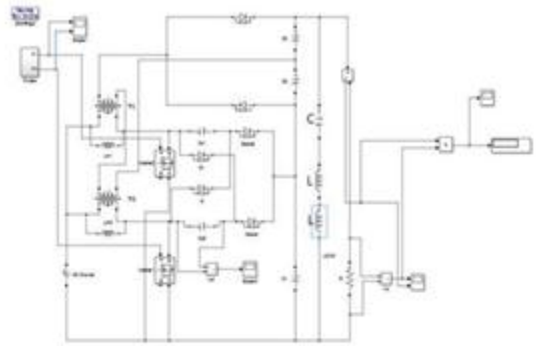

Fig.2.10: Circuit diagram of Multiphasing half wave converter with CLL filter

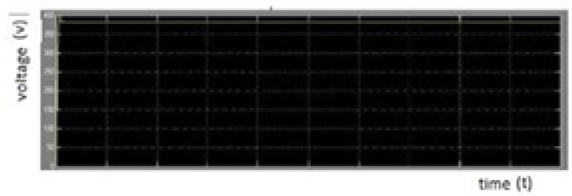

Fig.2.11: Output voltage

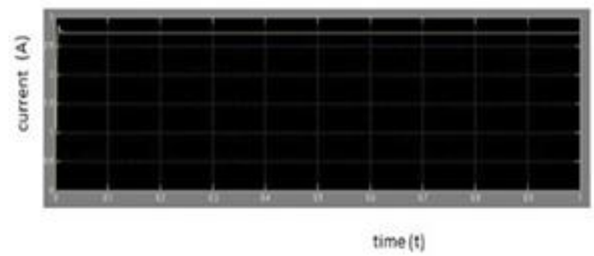

Fig.2.12: Output current

2.1.5 Multiphasing half wave converter with CLC Filter

Fig.2.14: Output voltage

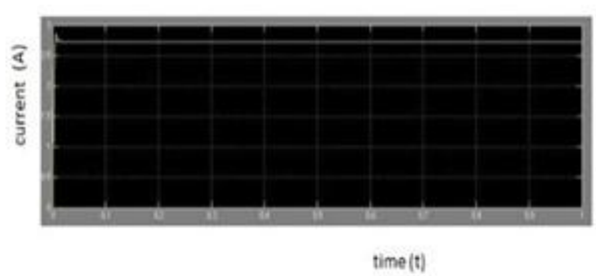

Fig.2.15 Output current

2.1.6 Multiphasing half wave converter with CCL Filter

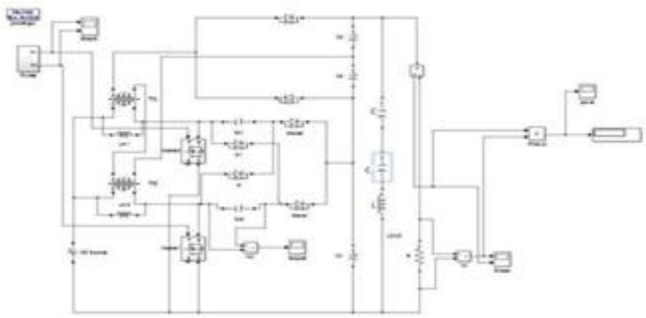

Fig.2.16: Circuit diagram of Multiphasing half wave converter with CCL filter

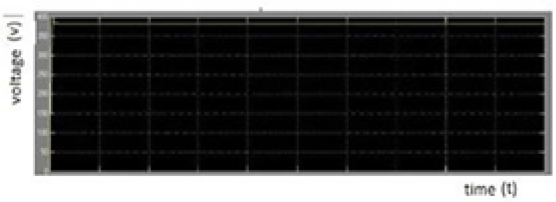

Fig.2.17: Output voltage

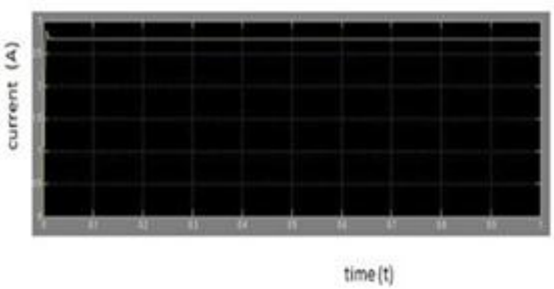

Fig.2.18: Output current

Table.2.2 Comparison Table

PARAMETRES	VOLTAGE	CURRENT	POWER
LCL Filter	640 V	0.05 A	26 W
CLC Filter	640 V	0.06 A	24 W
LLC Filter	650 V	0.002 A	5 W
LCC Filter	640 V	0.03 A	19 W
CCL Filter	635 V	0.04 A	25 W
CLL Filter	630 V	0.02 A	12 W

Table.2.3 Comparison Table for LCL Filter

PARAMETERS	VOLTAGE	CURRENT	POWER
L=10 mH, C=10microF L=1 mH	640 V	0.05 A	26 W
L=10mH, C=10microF L=10mH	640 V	0.06 A	28 W
L=15mH,C=40microF L=1mH	650 V	0.002 A	5 W
L=20mH,C=40microF L=15mH	660 V	0.001 A	3 W
L=1mH,C=50microF L=15mH	630 V	0.04 A	24 W

2.2 CLOSED LOOP SYSTEM

2.2.1 Closed Loop Multiphasing half wave converter with PI Controller

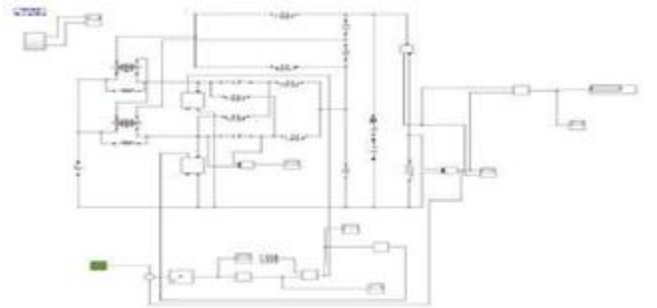

Fig.2.19: Closed loop Multiphasing half wave converter with PI controller

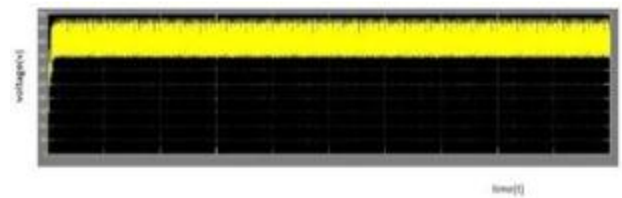

Fig.2.23: Output voltage

2.3.3 Closed Loop Multiphasing half wave converter with Fuzzy PID Controller

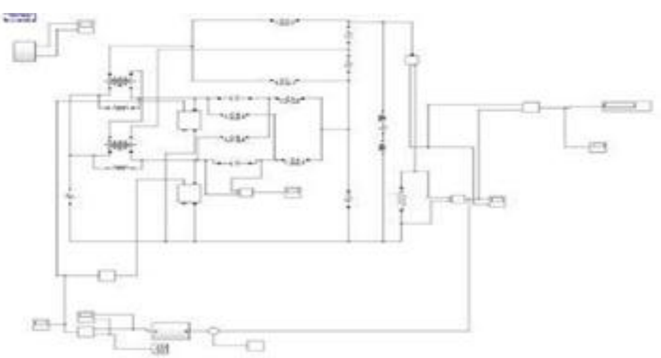

Fig.2.2.3: Closed loop Multiphasing half wave converter with fuzzy PID controller

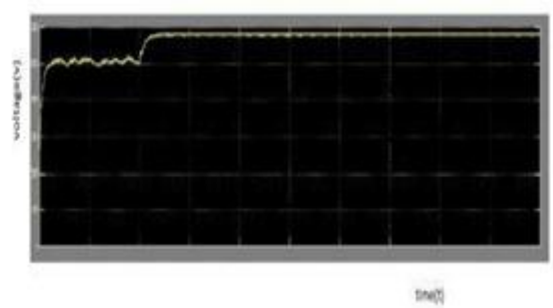

Fig.2.26: Output voltage

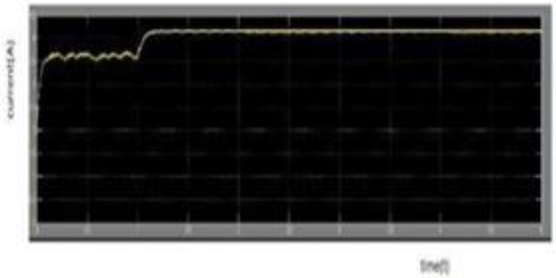

Fig.2.27: Output current

2.3.4 Closed Loop Multiphasing half wave converter with SMC

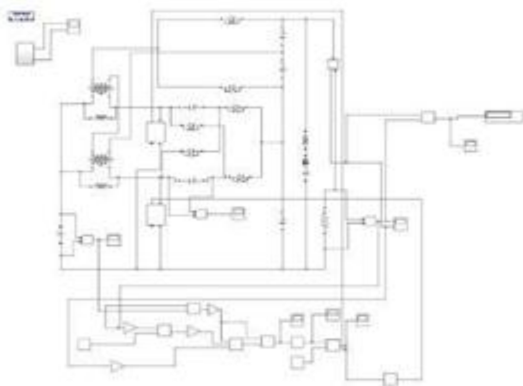

Fig.2.28: Closed loop Multiphasing half wave converter with SMC

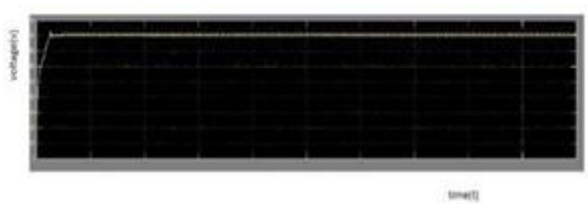

Fig.2.29: Output voltage

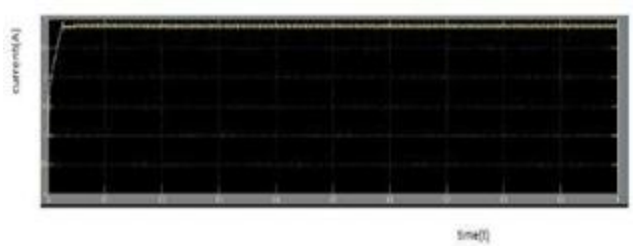

Fig.2.30: Output current

Table 2.4 Comparison Of Closed Loop Controller Using Time Domain Analysis

PARAMETERS	RISE TIME	PEAK TIME	SETTLING TIME
PI	0.1	0	0.6
FUZZY	0.5	0	0.1
SMC	0.1	0	0.08
FUZZY PID	0.2	0	0.03

Table 2.5 COMPARISON OF CLOSED LOOP CONTROLLER

PARAMETERS	PI	FUZZY	FUZZY PID	SMC
VOLTAGE	200 V	400 V	450 V	400 V
CURRENT	1.4 A	3 A	3 A	3 A
POWER	300 W	1200 W	1422 W	1200 W

III HARDWARE RESULTS

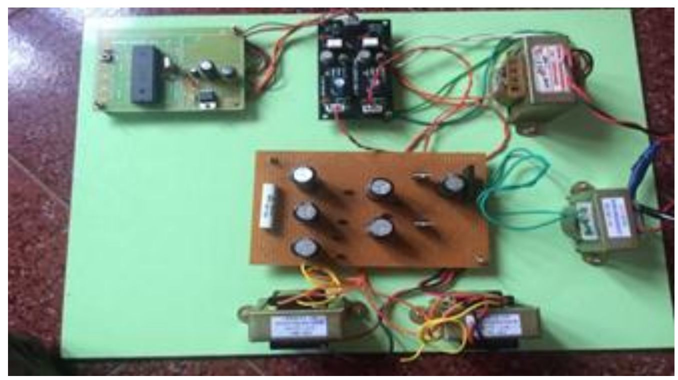

Fig.3.1: Hardware layout

The Multiphasing half wave converter is developed and tested in the laboratory. The hardware components such as driver circuit, PIC microcontroller, Transformers and Filters are used. The multi-phasing half wave converter is able to achieve high step-up voltage gain by adjusting the turn's ratio of the transformer winding. Thus, the synchronous employment of coupled inductors and switched capacitors leads to high step-up gain, high efficiency and low voltage stress. Hence the proposed converter reduces the current stress but also constrains the input current ripple, which decreases the conduction losses and lengthens the lifetime of the input source.

Table.3.1 Hardware Parameters

PARAMETERS	RATINGS
L	10mH
C	10µF
$L_{K1}=L_{K2}$	10mH
$C_1=C_2=C_3$	1000µF
R LOAD	4KΩ
TRANSISTOR	5 V
DIODE(IN4007)	5 V
REGULATOR(7805)	5 V
MOSFET(IRF840)	5 V
PIC MICRO CONTOLLER(PIC16F877A)	5 V

Fig.3.2 Input voltage from Multimeter

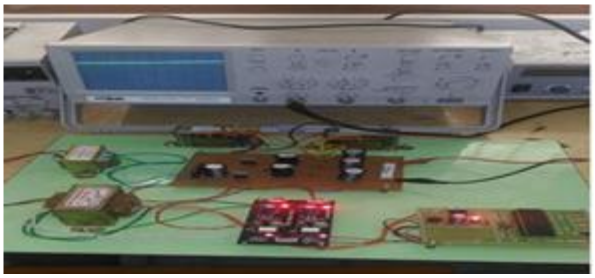

Fig.3.3 Input voltage from CRO

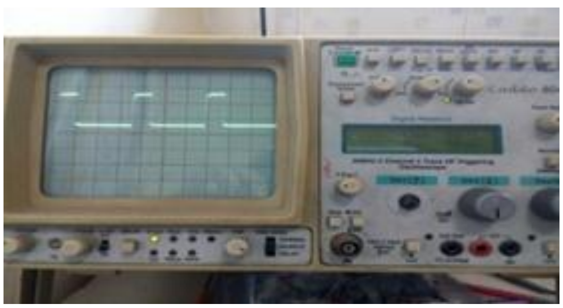

Fig. 3.4 Pulse waveform

Fig. 3.5 Transformer output voltage

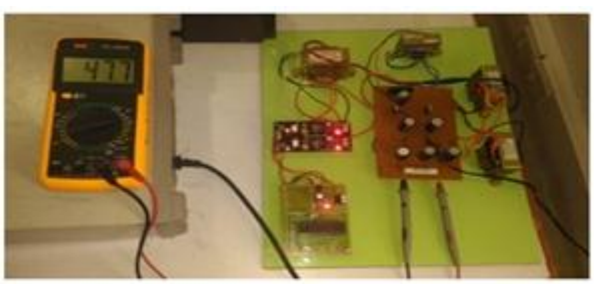

Fig. 3.6 Output voltage from multimeter

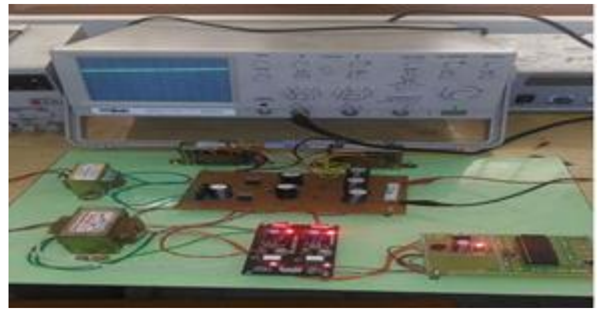

Fig.3.7: Output voltage from CRO

CONCLUSION

In is this paper Multiphasing Half Bridge converter with voltage doubler is used for HVTEQ. By using this converter high voltage ramp is generated, the voltage is smooth and it varies from zero to desired value. All hipot testers of sps electronic and fully electronic with analog and digital technology. The proposed converter is designed in open & closed loop by using MATLAB simultaneously .The proposed conversion provides good isolation smaller peak to peak variation and low ripple voltage. In open loop system the proposed conversation is simulated using six type of filters from that LCL filter result in better output with less ripple voltage In the closed loop comparison is done by using PI ,FUZZY controller ,FUZZY PID and SMC the FUZZY PID controller result in negligible Rise time, peak time and settling time ,the FUZZY PID controller gives better output and the steady state error is less. The proposed converter is implemented and it result in high step up conversion the multi phasing scheme reduces the current that pass through each power switch and reduce the input ripple current the hardware result indicates that leakage energy is recycled through the capacitor. The voltage stress in reduced.

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