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A 250 W Full Bridge DC-DC Stepup Converter

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Abstract—*This paper presents the design of a phase-shifted full-bridge series resonant converter (PS-FB SRC). The proposed FB SRC features a novel two-mode operation. It is operated in series resonant mode at normal loads..The proposed converter generates one output with a single input source. This paper covers operation of full bridge converter with wide input range of (22 V- 30 V). Converter along with power circuit, control circuit, input filter and resonant tank circuit is discussed in this paper. The power circuit is energized from a dc input voltage and full bridge converter with switching element MOSFET is switched ON and OFF using PWM controller UC1895 with switching frequency of 100 kHz. Simulation is carried out using ORCAD and testing results are tabulated in this paper.*

Keywords: *Phase-shifted full-bridge converter, series resonant converter (SRC).*

1. INTRODUCTION

Recently, resonant converters have attracted much attention because of their ability to operate efficiently at higher switching frequencies than conventional PWM converter topologies. Assuming that the efficiency can be maintained while increasing the operating frequency, proportionally lower values of energy storage elements yield smaller and lighter power converter with resonant switches, also known as zero current switching (ZCS) and zero voltage switching (ZVS) switches. Modern electronic systems require high-quality, small, lightweight, reliable, and efficient power supplies. Linear power regulators are limited to output voltages smaller than the input voltage and also their power density is low because they require low frequency (50 or 60 Hz) line transformers and filters. Linear regulator is confined to produce only a lower regulated output from higher non-regulated input. Regulation efficiency of linear regulator is low, resulting in power loss. To overcome the limitations of linear regulator, switched mode power supplies are used as alternative in most of modern electronic applications. Switching regulators use transistor switch to generate square waveform from a non-regulated DC input voltage. This square wave with adjustable duty cycle is applied to low pass outputfilter to obtain regulated DC output. They generate buck, boost and inverted outputs. Isolated and non-isolated converters are two types of switched mode power supplies among which buck, boost and buck-boost are non-isolated converters, whereas flyback, push-pull, full- bridge and half -bridge are isolated converters. For applications requiring high power outputsisolated converters are employed. Design of full bridge converter with high voltage and low current converters is a remarkable challenge. Full bridgetopology is widely used in high power applications. The transformer in full bridge converter (Usually known as coupled inductor) is used to achieve electrical isolation and energy storage. High switching devices such as MOSFET/IGBT is used as switching device and soft switching is employed, due to which although switching losses are nearly eliminated in resonant converters ,the peak MOSFET stress and hence conduction losses are substantially decreased. This results in good efficiency.

2. FULL BRIDGE CONVERTER

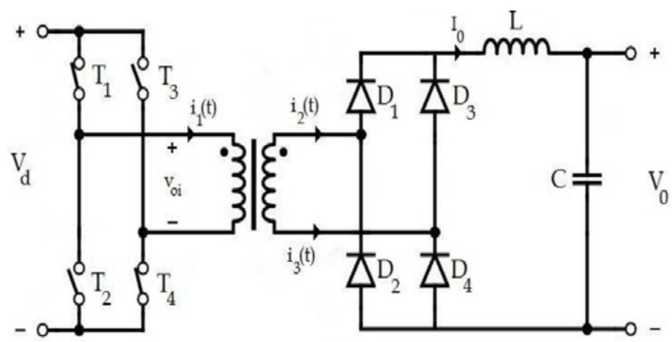

Fig. 1: (a) Full Bridge converter

The switching topology used for the full-bridge converter is the bipolar voltage switching, where the MOSFETS are switched in pairs[1]. MOSFET T1 and T4 are considered as one switch pair and MOSFET T2 and T3 are considered as the other switch pair. The Basic circuit diagram of Full Bridge converter is shown in the Fig..

The output voltage V0 is controlled and regulated by the PWM scheme seen in Fig. 1(b) where a sawtooth signal is compared with a voltage control signal from the control circuit. During the first half period, the switchpair T1 and T4 are conducting as long as the sawtooth signal is lower than the control signal. When it exceeds the control signal the transistors stops to conduct until the second half period takes place when the switch-pair T2 and T3 starts to conduct until the sawtooth signal yet again exceeds the control signal. This procedure repeats itself from period to period.

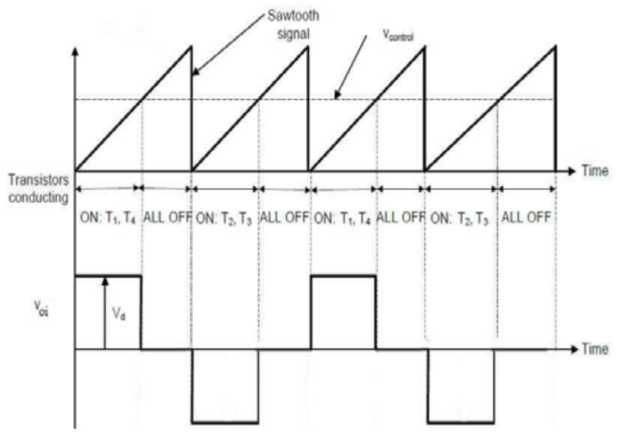

Fig. 1: (b) Full Bridge converter switch topology

Another type of control is the phase-shift control which provides a convenient method for achieving zero voltage switching, significantly reducing the switching losses. Stored energy is then used to charge and discharge bridge switch capacitance during a freewheeling stage created by phase shifting the ON times of opposite pairs of transistors in the bridge configuration.

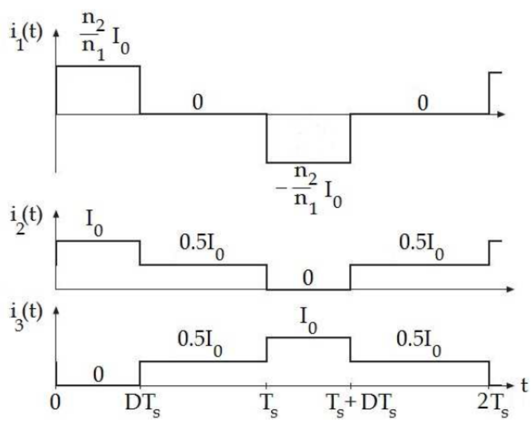

Fig. 1: (c) Current waveform of primary and secondary

The current waveform on the primary and secondary side can be seen below in Fig. 1(c) and by using these current waveforms, the RMS currents can be expressed as

$$\text{I1rms}=\sqrt{\frac{1}{2Ts}\int_0^{2Ts} i1^2 dt} = \frac{n2}{n1}\text{I}_{\text{onmax}}\sqrt{D} \quad (1)$$

$$\text{I}_{\text{2rms}}=\text{I3rms}=\sqrt{\frac{1}{2Ts}\int_0^{2Ts} i2^2 dt} = \frac{1}{2}\text{I}_{\text{onmax}}\sqrt{D+1} \quad (2)$$

The resulting output voltage V0 is therefore directly related to the transistors resp. on-state time and this relationship can be derived by integrating the voltage voiover one time period Ts and then divide it by Ts. The average value of voi is then given by

$$\text{V0}=\frac{1}{Ts}\int_0^{Ts} voi(t) = \frac{1}{Ts}\left(2\int_0^{ton}\frac{N2}{N1} vddt + \int_{-\tau}^{\tau 1} 0\, dt\right) \quad (3)$$

This equation gives the transformer setup for the full bridge converter

$$\frac{V0}{Vd} = 2\frac{N2}{N1}\text{D} \quad (4)$$

3. CIRCUIT DIAGRAM AND DESCRIPTION

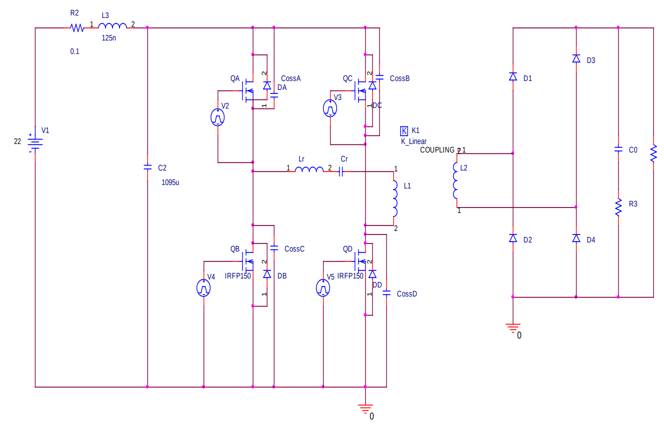

Fig. (2): Circuit diagram of proposed full bridge converter

Fig. 2 shows the schematic of a full-bridge SRC[3]. The primary side contains four active switches, *QA &QD*, with their output parasitic capacitors *Coss,A&Coss,D*, the resonant capacitor *Cr*, and the resonant inductor *Lr*. The turns ratio of a full bridge transformer is *n* : 1. The secondary side includes rectifier diodes *D1,D2*, D3,D4 a filter capacitor *CO*, and a load *RL*. The duty cycle of the primary-side active switch is about 50%. Bipolar pulse-width modulation (PWM) scheme is adopted. That is, the control signals of *QA/QD* and *QB/QC* are complementary. Dead times preventing the simultaneous conduction of the switches are inserted to delay the turn-ons of the switches. When *QA* and *QD* or *QB* and *QC* conduct, the input power is transferred to the output load. Zero-voltage switching are achieved by the resonance of connection of *Cr* and the output parasitic capacitors of the switches during dead times.

The proposed converter generates 270 V with 0.9A current to give 250W power. Primary side of transformer is energized from input DC source (22 V-30 V). MOSFET is used as switching device operating at 100 KHz switching frequency. Maximum duty cycle at which converter operates is 0.9 and ripple voltage is kept below 270 mV.

A Specifications:

1. *Input specification:*

V_{in} Nominal = 28 V

$V_{in\ min}$= 22 V, $V_{in\ max}$ = 30 V

Emergency operation**:** DC steady state voltage shall be between 22-30 V and is taken care by design.

2. *Output specifications:*

   V_0=270 V

   I_0=0.94 A

3. D_{max} limited to 0.9
4. Dmin=0.66
5. Efficiency = 85%
6. Switching frequency, fs = 100 KHz
7. Ripple voltage = 270mV$_{p\text{-}p}$ (max)
8. Output power = 250 W
9. Input power = 294.11 W

4. SIMULATION CIRCUIT AND WAVEFORMS

The proposed converter is designed and simulated using ORCAD software.The simulated results are given below. The proposed converter is shown in the Fig. (3).

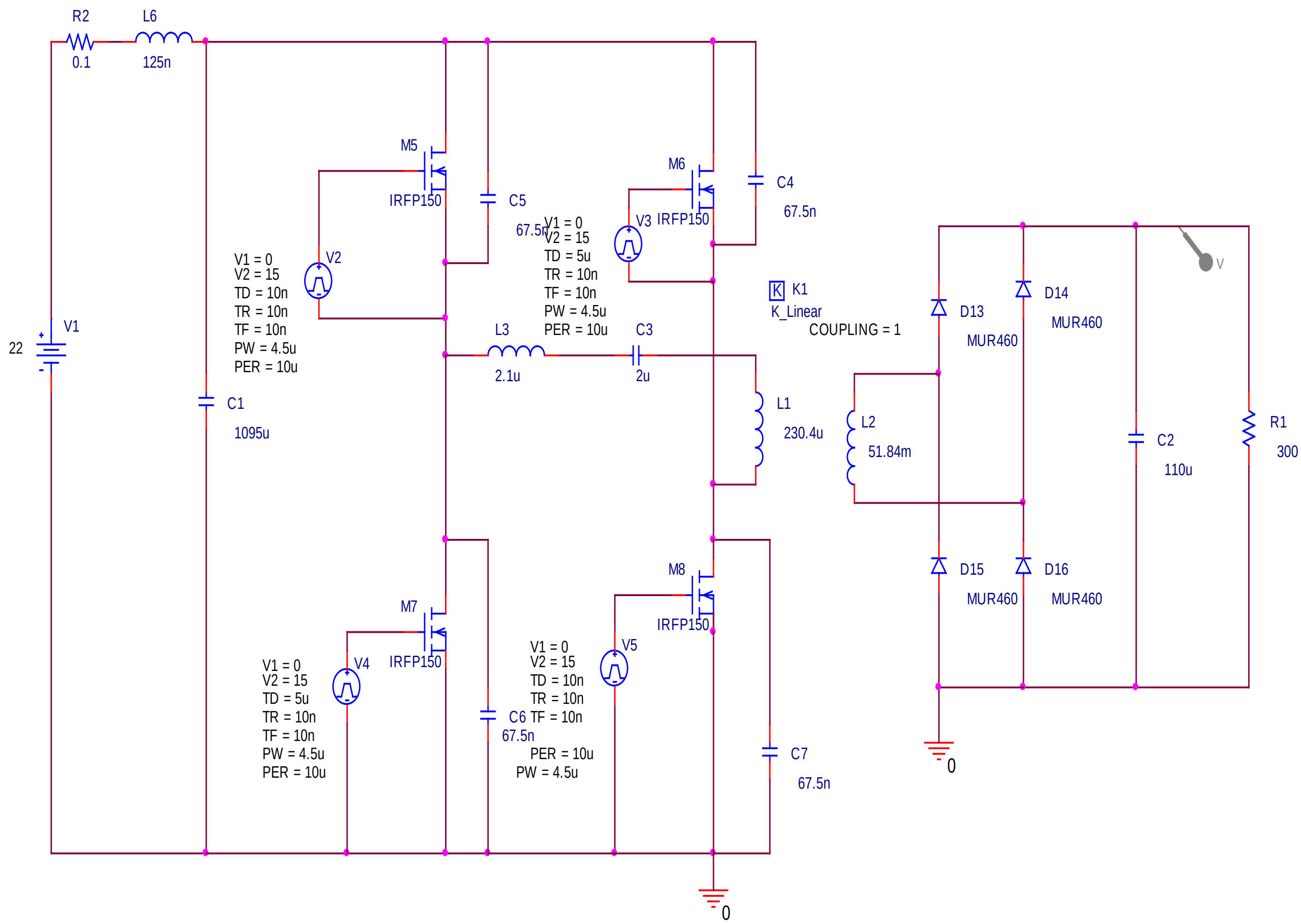

Fig. 3: Simulation circuit of Full Bridge converter.

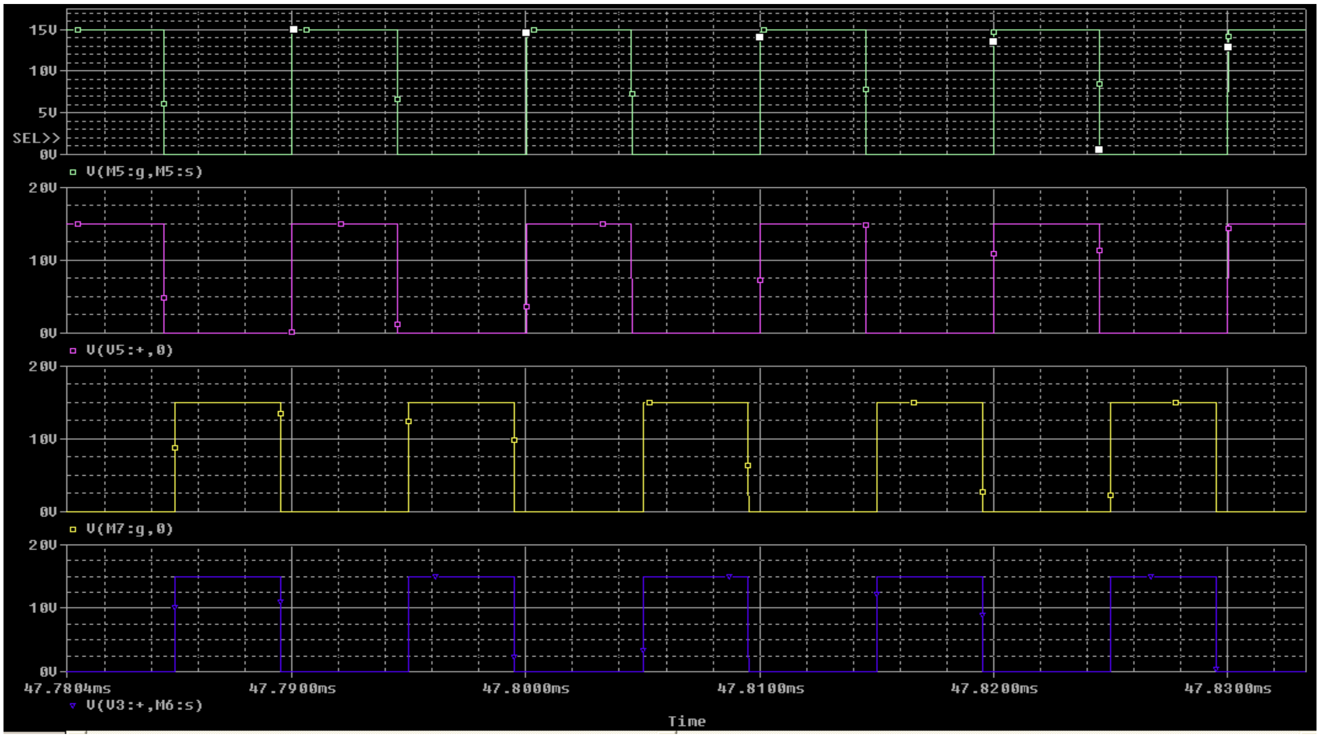

Fig. 4: Gate pulses

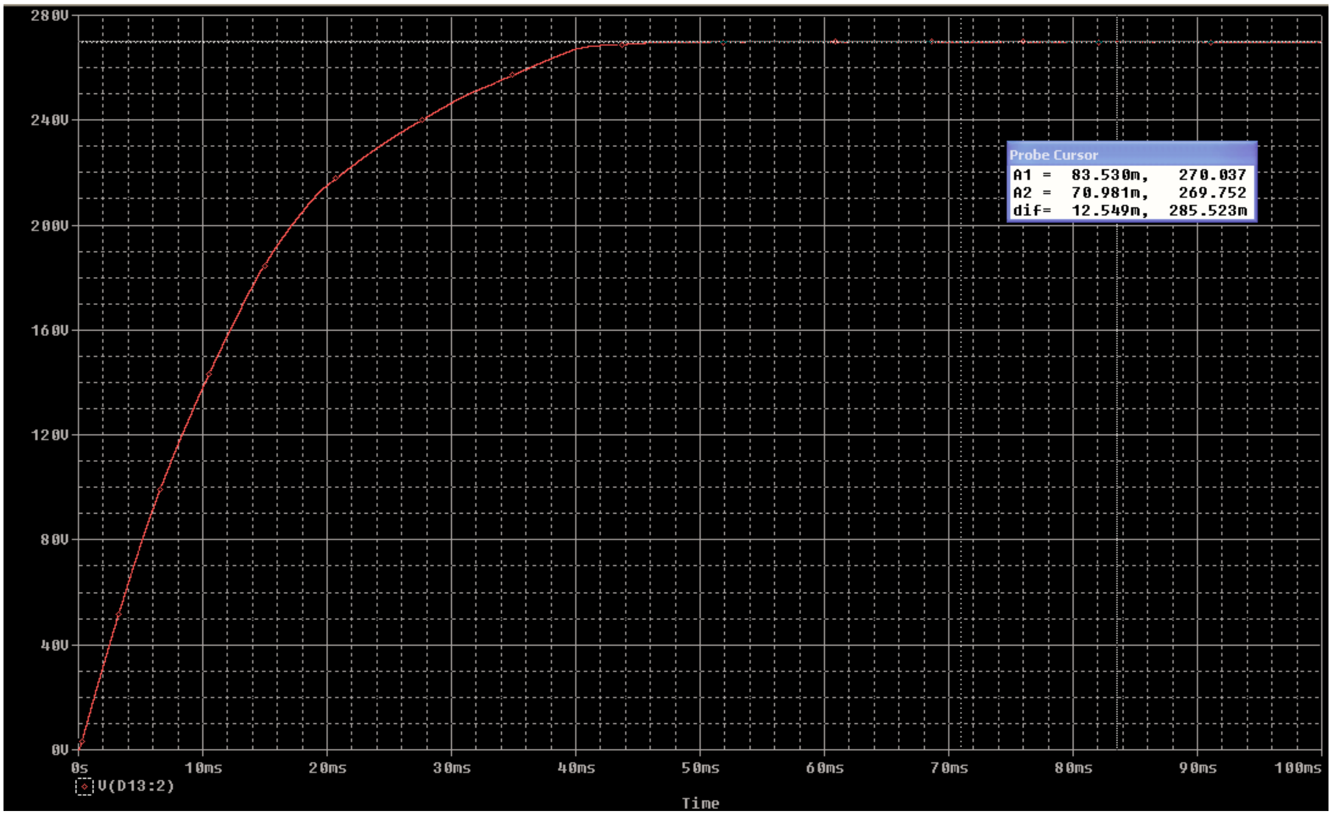

Fig. 5: Output Voltage across output capacitor.

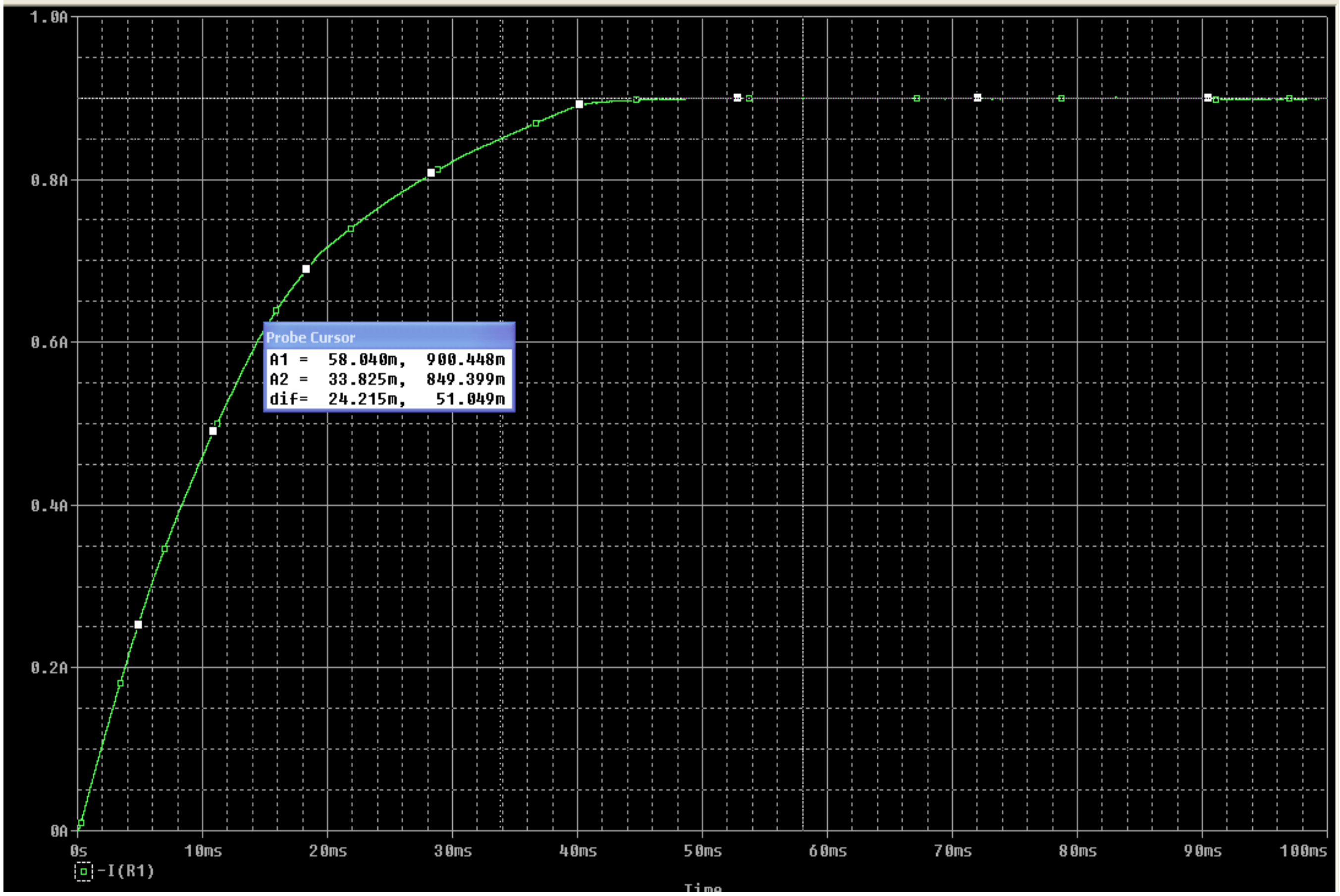

Fig. 6 : Output Current across load

The above graph are the simulated results of proposed converter. Fig. 4 shows gate pulses and Fig. 5 & 6 gives Voltage and Current waveforms.

5. EXPERIMENTAL RESULTS:

A prototype of Full Bridge converter with voltage mode PWM IC UC1895 has been built and tested.

THE complete test set up view of the proposed converter is as shown

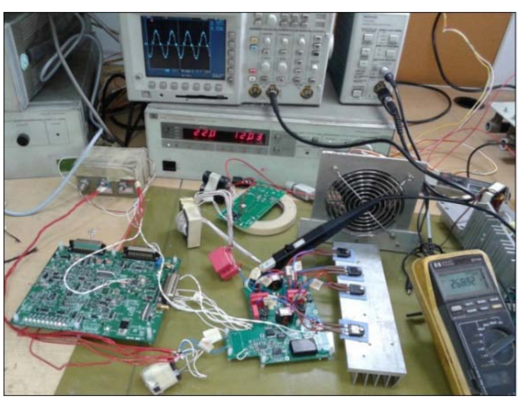

Fig. 7: Experimental setup

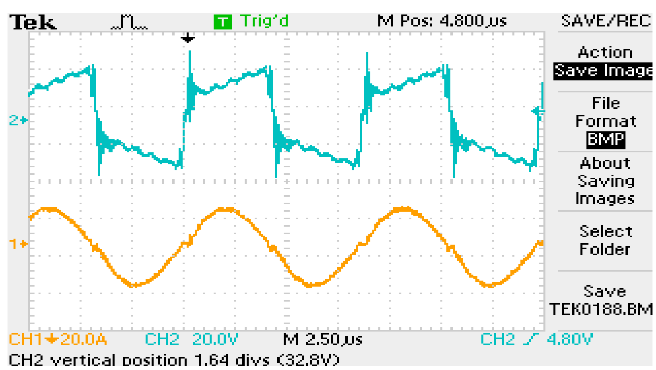

Fig. 8: Voltage and current Waveform

Fig. 8 explains voltage and current waveform of the proposed converter.

HARDWARE EXPERIMENTAL RESULTS:

Table 1 and Table 2 gives experimental results of proposed converter.

LINE REGULATION

As the variation of output voltage with respect to varying input voltages for constant load current with full load.

Table 1 Experimental results of prosed converter

Sl No	Vin (volts)	Iin(Amps)	Vout(volts)	Iout(Amps)
1	22	12.99	271.32	0.87
2	24	12.10	271.32	0.87
3	26	11.84	271.32	0.87
4	28	11.63	271.32	0.87
5	30	11.40	271.32	0.87

Load Regulation

As the measure of variation of output voltage with respect to varying load current for constant voltage input, tjat is to carry out load regulation input voltage is kept constant ,then output load current varying slightly by varying load resistance.

Table 2: Results of Load regulation

Sl No	Vin (volts)	Iin(Amps)	Vout(volts)	Iout(Amps)
1	28	1.78	271.34	0.13
2	28	5.68	271.32	0.40
3	28	11.63	271.32	0.87

6. CONCLUSION

The full bridge converter is designed and implemented for the given specifications. The converter was designed for input range of 22 V to 30 V AC input voltage range, with 270V output, 250 W full load output power and output voltage ripple less than 270 mV. The converter designed is shown to work satisfactorily within given limits maintaining constant regulated output with minimal ripple. The load regulation is shown to be very low, hence demonstrating the converter's ability to account for variations in supply voltage and load to maintain constant(regulated) output. The circuit is simulated using ORCAD and the relevant waveforms are obtained.

7. ACKNOWLEDGEMENT

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