speed and more powerful ability in executing complex control algorithm. Thus, this prototype adopts DSP as the controller hardware.

In experiment, the overall system consists of six parts. The power circuits (part 1) regulate the output voltage of the ac chopper converter to obtain the desired compensation voltage. The signal detection circuits (part 2) use the voltage sensors and the signal conditioning circuits to measure and filter the signals of the power source voltage and the load voltage. The controller (part 3) includes the DSP running the proposed control algorithms. The feedforward and feedback control algorithm of the proposed voltage regulator is implemented using 30MIPS DSPIC30f4011. This processor is designed for high performance applications and has a variety of peripherals. Switching period and duty ratio calculation are implemented in software. The PWM control signals are generated by the PWM function unit in DSP. Voltage signals obtained from the part 2 are converted by using the analog digital converter (ADC) function unit in DSP. The duty ratio is changed in every sampling period.

The driver circuits (part 4) convert the PWM control signals generated by the controller into the driver signals of the IGBT in the power circuits. The faults protection circuits (part5) can disable all PWM control signals and show the faults types when over-currents, over-voltage or over-heat faults occur. The auxiliary power supply (part 6) provides the +5V dc power to part 3, ±15V dc power to part 2, +24V dc power to part4.

Fig.12 shows the picture of the prototype. The circuit parameters in experiment are shown in Table.3.

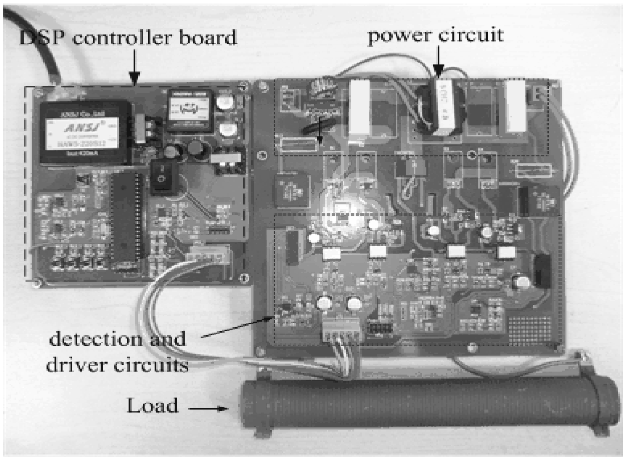


Fig.12 prototype of the proposed dynamic voltage regulator

Item	Symbol	Parameter
Source voltage	u_s	$\sqrt{2}60\sin(314)t$
input filter inductor	L_i	$0.2mH$
input filter capacitor	C_i	$1\mu F$
output filter inductor	L	$1mH$
output filter capacitor	C_o	$1\mu F$
IGBT	$S1,S2,S3,S4$	600V/10A
SSR	$SW1,SW2,SW3,SW4$	380V/5A
switching frequency	f_s	40kHZ
sampling frequency	f_{sam}	5kHZ

Table 3 the parameters of the prototype in the experiment

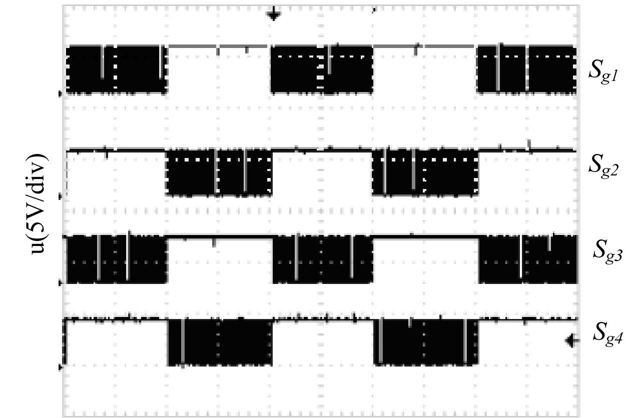


Fig.13 PWM control signals of the ac chopper converter

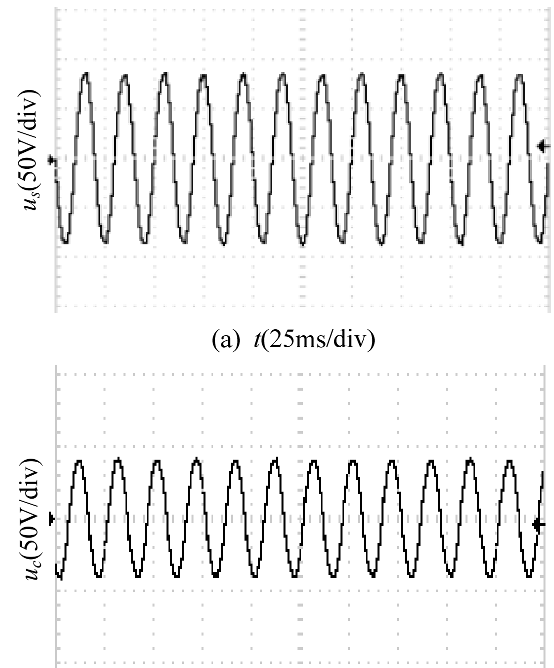


Fig.14 the waveforms of (a) power source voltage u_s (b) the compensation voltage u_c

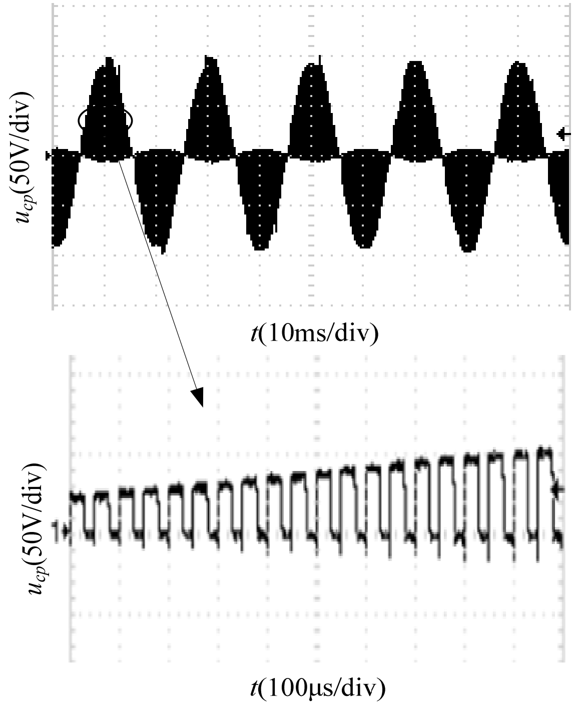
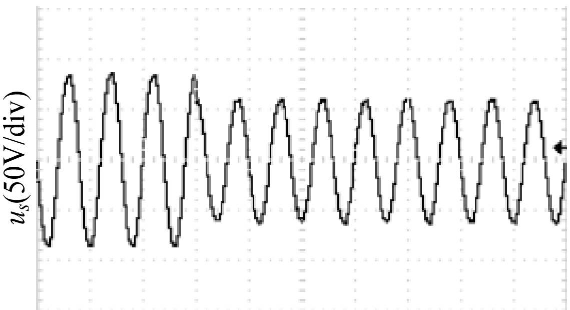
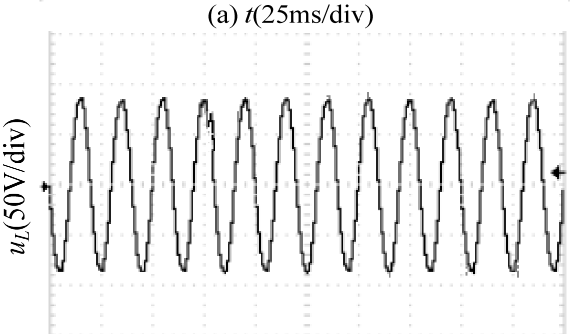


Fig.15 the waveforms of the intermediate chopper voltage u_{cp}



(a) t(25ms/div)

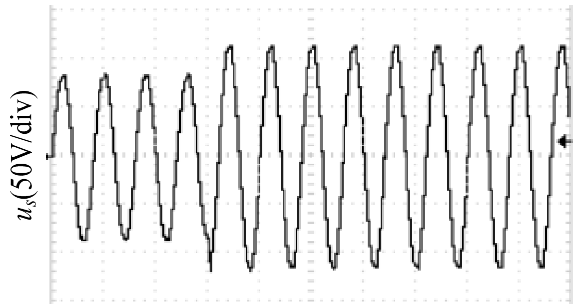


(b) t(25ms/div)

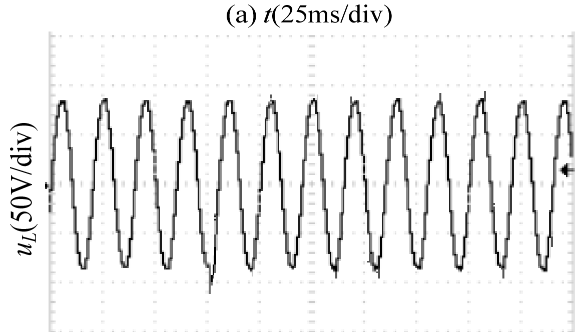
Fig.16 when voltage sags occur, the waveforms of (a) the power source voltage and (b) the load voltage

The designed commutation process shown in Fig.4 is also realized. The PWM control signals corresponding to the commutation strategy are shown in Fig.13. Fig.14 illustrates the source voltage u_s and the compensation voltage u_c, when D=0.5. The compensation voltage is nearly sinusodial waveform. Fig.15 shows the waveforms of the intermediate chopper voltage u_{cp}. The input voltage is chopped into segment. In addition, by using the designed commutation strategy, there are no voltage spikes in u_{cp}. The snubber circuits are not needed in this design.

Fig.16 shows the performance of the approach for the 30% voltage sags. Fig.17 shows the results of the approach for the 30% voltage swells.



(a) t(25ms/div)



(b) t(25ms/div)

Fig.17 when voltage swells occur, the waveforms of (a) the power source voltage and (b) the load voltage

With the proposed topology and control method, the output voltage is nearly unaffected with the suddenly supply voltage change. The feedforward and feedback controller can regulate the duty ratio and keep output voltage stable. These results verify the validity of the proposed method.

5 Conclusion

A novel topology of dynamic voltage regulator design using transformer and PWM AC chopper converter is proposed. This topology does not use energy storage devices, such as battery, bulk capacitors or inductors. The sinusoidal compensation voltage and input current waveforms can be obtained. In addition, the feedforward feedback instantaneous voltage control strategy is designed to enhance the performance of the converter. When input voltage sags and swells occur, the compensation voltage can be regulated by changing the duty ratio of the PWM signals to keep the load voltage stable. The proposed converter and control strategy present the advantages of fast dynamic response and effective compensation to the voltage fluctuations. Simulations are performed to investigate the performances of the proposed converter. The prototype is designed by using DSP to implement the control algorithms. The simulation and experiment results shows that it has fast transient response, and can keep the load voltage stable effectively.

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