Design and Simulation of 160V DC Regulated Power Supply for Enhanced Oil Recovery

Jianjun Xu [1], Lianwei Zhang [1], Yang Pu [2], Jingchun Wu [1], Jicheng Zhang [1], Limei Yan [1,*], Hongyu Li [1], Linlin Dong [1]

[1]Department of Electrical Information Engineering, Northeast Petroleum University, Daqing, 163318, China

[2]Natural Gas Company of Daqing Oilfield Limited Company, Daqing, 163453, China

Corresponding Author: Yan Limei, 123939274@qq.com

Abstract

The circuit is designed to meet the conditions under which the oil recovery is enhanced under a DC electric field.The minimum voltage stress passive lossless Buck buffer circuit, soft switching technology and dual closed-loop control circuit are combined to design a regulated DC power supply, and given the design part of the circuit diagram and the realization of the process, providing stable DC output to an external DC electric field. Finally, in the MATLAB software to build simulation model to complete the DC power supply design and design feasibility verification.

Keywords

Direct Current (DC) electric field, PWM, MATLAB.

1. Introduction

Nowadays, by external direct current electric field to enhance the ratio of oil recovery is a new technology to improve oil recovery[1-3]. As the shortage of petroleum and gas resources has been a major problem for all countries in the world. Our country's major permeability oil fields in intermediate or advanced have entered the high water cut stage[4]. But most of the discovered reservoirs are low permeability reservoirs, so the method we used before can not meet the new technical requirements[5].And the method of enhancing oil recovery by external electric field has a great future.

The research shows that the effect of the applied electric field on the water saturation in the gap model of the low permeability slit medium is more obvious, and when the applied DC electric field is 160V, the effect is obvious in the different slot width model. It is determined that 160V is the optimum electric potential of the applied electric field.

2. DC regulated power supply circuit components

In this paper, the design and simulation of DC regulated power supply are completed in MATLAB simulation software,

In this paper, the use of MATLAB simulation software for DC power supply design, circuit structure shown in Figure 1

The analysis of the work process of DC regulated power supply:The input is 220V AC, through the protection circuit, full bridge uncontrollable rectifier, the voltage becomes DC 310V. Using soft switching technology to achieve the purpose of reducing the loss of Buck voltage conversion. In order to avoid the input voltage fluctuation to ensure that the output is stable, adding a negative feedback adjustment part, sampling voltage and current in the post-stage output , the adjustable PWM pulse signal can be produced by sampling, comparison and amplification of several steps to control the switch and then make the appropriate adjustment to stabilize the output.

The design of the 160V DC power supply can be divided into three parts: The first part of the input circuit is not controllable rectifier module, the circuit module function is to ensure that the input AC voltage is stable and reliable, and voltage rectification.The second part is the Buck buffer circuit, its function is to use soft-switching technology to reduce the voltage stress switch, than it can reduce losses and reduce interference to maintain voltage stability.The third part is the double closed loop control circuit of PWM signal, this circuit module can ensure that the control circuit generates PWM control signal, so that the output voltage is maintained at 160V, can also realize voltage stabilizing function.

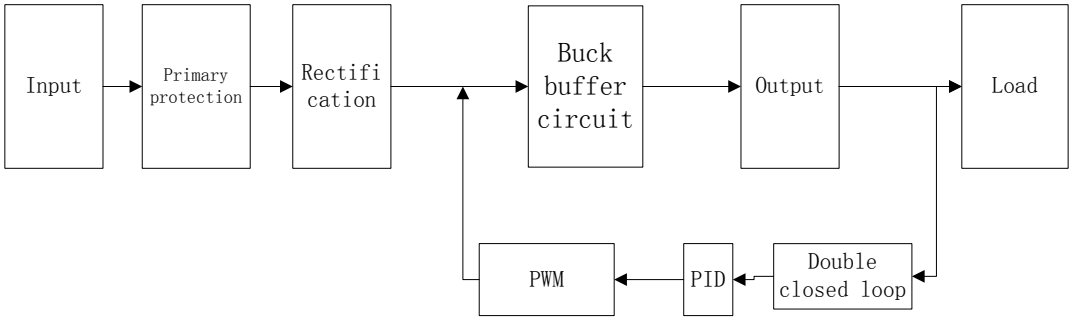


Figure 1. DC regulated power supply circuit components

3. Analysis of the 160V DC stabilized power supply model

Figure 2 is the 160V DC regulated power supply circuit MATLAB simulation model, the model of the components are designed according to the given. The circuits reach to steady state after a period of time, the Figure of the uncontrolled rectifier output voltage, the PWM control signal, the whole circuit simulation graph input voltage, output voltage and output current are demonstrated in the oscilloscope.

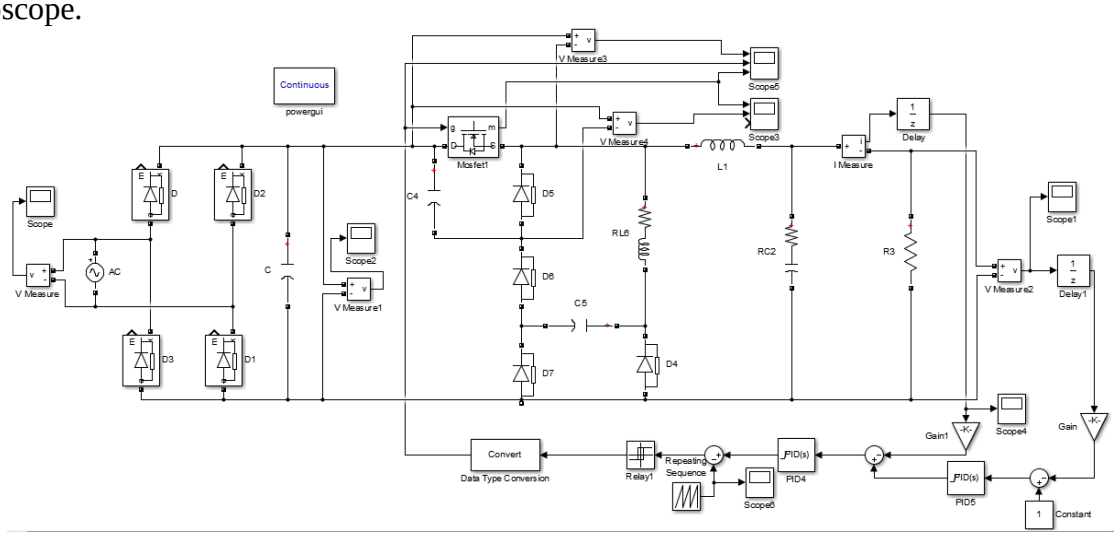
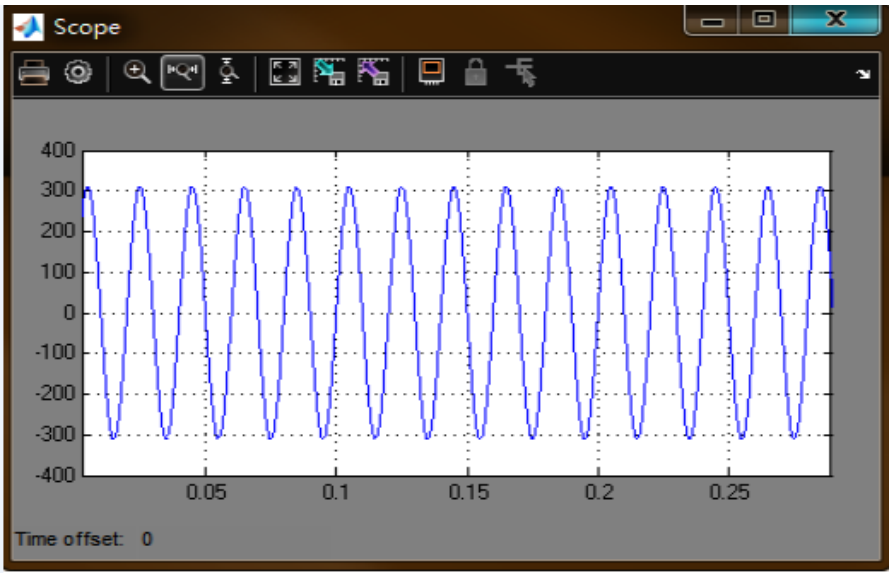
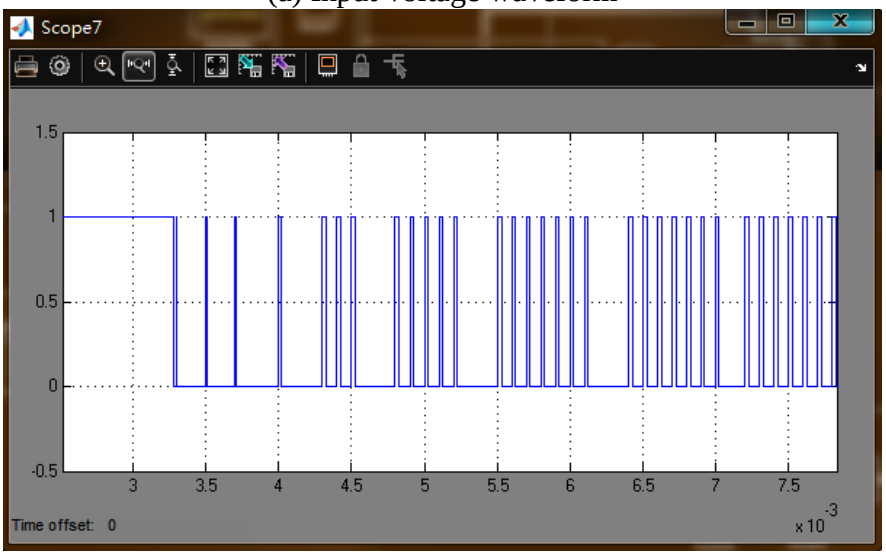


Figure 2. 160V DC regulated power supply simulation

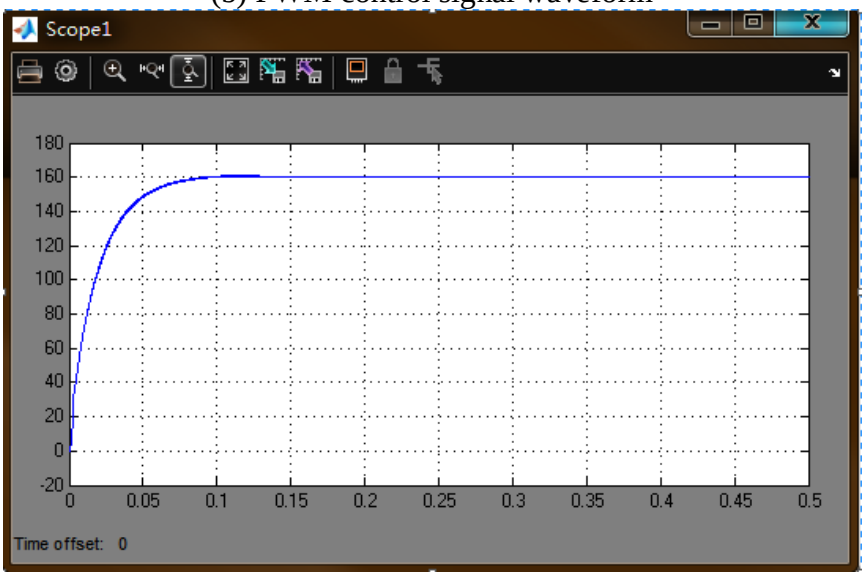
For the convenience of observation, the input voltage, the PWM control signal and the output voltage and current waveform of the whole circuit are given in figure 3(a)-(d).



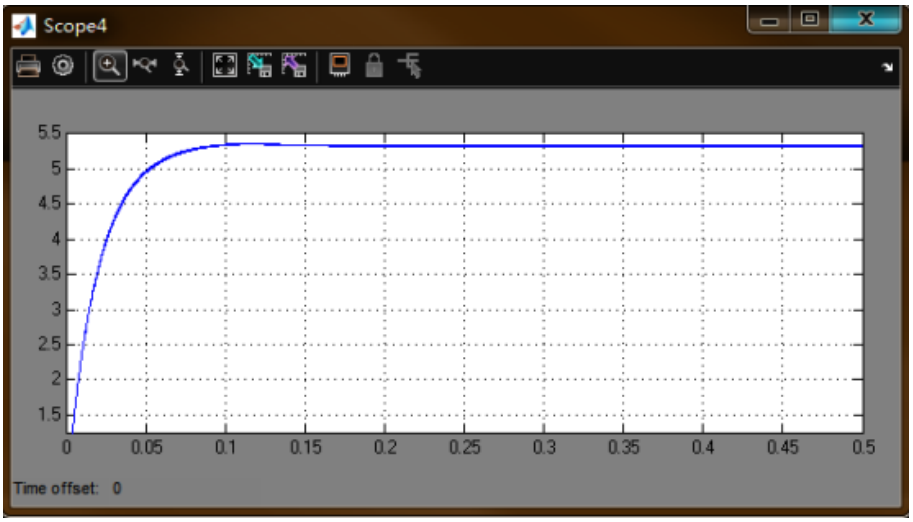
(a) Input voltage waveform



(b) PWM control signal waveform



(c) Overall voltage output waveform



(d) Overall circuit output current waveform

4. Conclusion

This paper combines the Buck buffer circuit, soft-switching technology and double closed-loop control circuit to design 160V regulated DC power supply. The overall circuit structure of the DC power supply is given, and the simulation verification of the 160V regulated DC power supply is carried out in the simulation software MATLAB. And finally it proved that the design of the power supply is stable, reasonable and reliable.

Acknowledgments

This work is Supported by Northeast Petroleum University Innovation Foundation For Postgraduate (YJSCX2015-029NEPU).

This work is supported by PetroChina Innovation Foundation (2016D-5007-0201).

References

[1] Xu J J, Yuan Y Z, Duan Y B, et al. Enhancement of Oil Recovery via Direct Current[J]. Japanese Language & Literature, 2012, 147(3):179-183.

[2] Ghazanfari E, Pamukcu S, Karpyn Z, et al. Characterization of Oil-Bearing Sandstones for Sustainable Oil Production in Electrically Enhanced Oil Recovery[J]. Geotechnical Special Publication, 2014(234):515-523.

[3] XU Jian-jun, GAO Wen-feng, YUAN Ying-zi, et al. A circuit design for 150V regulated DC power supply in the field of oil field recovery by DC electric field [J]. Chemical Automation and Instrumentation, 2013, 40 (10): 1259-1262.

[4] SA Saeedi, M Keshtegar. Enhanced Oil Recovery Using Modern Methods of Microbial and Electric Energy[J]. Ci ência eNatura, Santa Maria, 2015, 37(1): 34−40.

[5] Koshy, Susan A. Experimental and numerical investigation of coupled radial electroosmotic flow and electric field using pi electrokinetic up-scaled reservoir model[J]. Dissertations & Theses - Gradworks, 2015.