

POWER FACTOR SIMULATION OF FOCUS QUADRUPOLE DC POWER SUPPLY OF WHITE CIRCUIT SYSTEM WITH MATLAB SIMULINK

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Abstract

The focus quadrupole DC power supply used at White Circuit system of booster ring of Synchrotron Radiation Research Center (SRRC) is a 19.2kw unit, but an AC power source to measure the power factor of such power supply with build-in power factor measuring function is very expensive. Power factor simulation of this power supply with MATLAB Simulink software is economic and laborsaving to figure out the performance of power factor, and the simulated results may be used to find some efficient ways to correct this parameter if necessary. The results from simulation model will be compared with the results of power factor monitored from direct measurement on AC mains. The model of quadrupole DC power supply is constructed and provided for better understanding for further modification.

1 INTRODUCTION

The focus quadrupole DC power supply[1] is to supply the quadrupole magnet of White Circuit of booster ring with direct current. The AC main input is 3 phase 380 V connected to the main transformer; the primary of input transformer of this power supply is a wye-winding and there are two windings on secondary side, one is a delta-winding and the other is a wye-winding. Each winding on secondary side of the input transformer is rectified in a 3-phase rectifier, this two rectified output is in series to perform 12-pulse waveform so the ripple ridding on rectified DC voltage could be lowered and filtered with a smaller L-C low-pass filter.

This power supply is a switched mode current source unit, and the output current of this power supply is controlled by a current controlled buck pulse width modulated IC. The switching power device of the modulated unit is a IGBT, and there are two modulated units paralleled to deliver enough current to the quadrupole magnet.

The main advantage of switched mode power supply is with higher efficiency than linear type power supply, but there are some shortage should be cared about, for example, the switching noise and lower power factor (it depends on what kind of load). If switching noise is too strong that will interfere all electronic circuit near about. Lower power factor means more power is wasted and larger wire should be used to carry higher current to power the power supply to serve enough current to load,

and high total harmonic distortion will interfere other electronic instrument via AC input wires.

MATLAB Simulink[2] is a powerful software package, it can simulate, model, and analyze dynamical system. It supports linear and nonlinear systems, modeled in continuous time, sampled time, or hybrid of the two. For modeling, Simulink includes a comprehensive block library of sinks, sources, linear and nonlinear components, and connectors; one of key features of Simulink is that it is built on top of MATLAB. As a result, Simulink users can access to the wide range of MATLAB-based tools for generating, analyzing, and optimizing systems implemented in Simulink. These over 20 tools package include MATLAB Application Toolboxes, specialized collections of M-files for working on particular classes of problems. The Power System Blockset is a design tool that allow users to rapidly and easily build models that simulate power systems. The libraries of Power System Blockset contain models of typical power equipments, such as transformers, lines, machines, and power electronics. It is easy to build the model of this quadrupole DC power supply with Power System Blockset, and in combination with another toolboxes the behavior of this power supply might be simulated as it really work.

2 MEASUREMENT OF POWER FACTOR AND TOTAL HARMONIC DISTORTION

In the laboratory of power supply group of SRRC, there is a 3-phase 9 kw AC power source to measure the parameter of input AC main of power supplies under 9 kw. The focus quadrupole DC power supply is a 120V, 160A, 19.2 kw power supply, so this AC power source is not able to supply enough energy and extract parameters. Without an ac power source with build-in measuring function to extract parameters of input AC main, direct measuring of input voltage and current waveform is the straightforward way.

Definition of power factor is as follows:

$$P = V_s I_{s1} \cos \phi_1, \quad S = V_s I_s$$

$$\text{Power factor PF} = P/S$$

$$\text{PF} = V_s I_{s1} \cos \phi_1 / V_s I_s = I_{s1} \cos \phi_1 / I_s$$

V_s : rms input voltage

I_s : rms input current

Figure 5 shows the model of UC3846 built with MATLAB Simulink. The protective function is not included in this model because it doesn't affect the result of simulation.

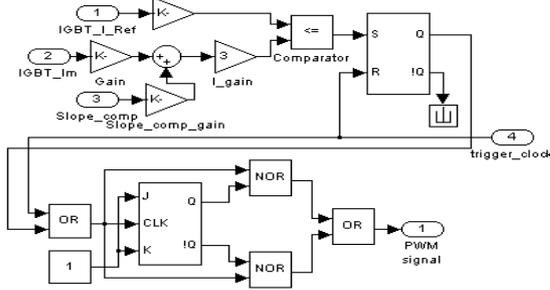


Figure 5. Model of UC3846 built with Simulink.

B. Model of Quadrupole DC Power Supply

Figure 6 shows the model of quadrupole DC power supply built with MATLAB Simulink. After building this model, it is easy to extract any parameter inside the model with libraries of Simulink; the most interesting parameter is ac input current, because power factor and total harmonic distortion could be calculated by MATLAB with this parameter.

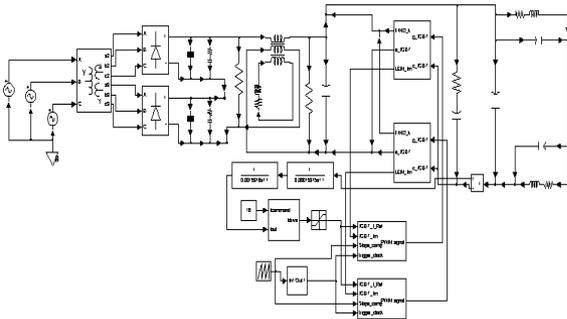


Figure 6. Model of quadrupole DC power supply built with MATLAB Simulink.

Figure 7 shows waveforms of real ac input current and simulated one while output current of quadrupole DC power supply is 160 amperes. Difference between these two waveforms is very small, these two waveforms are not perfect match might be due to the input transformer is not perfect ideal, every phase voltage waveform is not the same and delivers unbalance current.

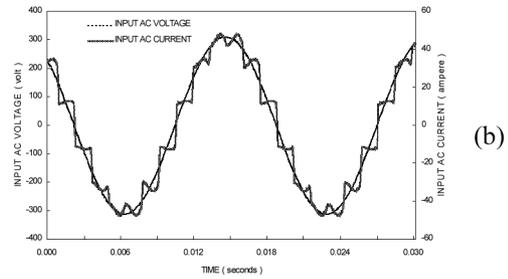
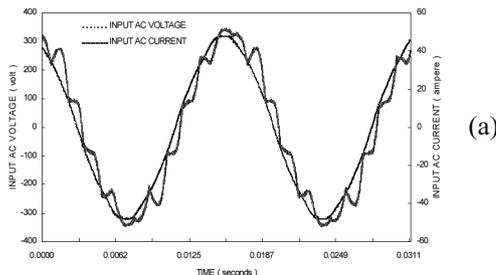


Figure 7. (a) AC input current waveform of measurement. (b) AC input current waveform of simulation.

Power factor is the most concerned performance of quadrupole DC power supply, and figure 8 shows power factor extract from simulation is very similar to real performance.

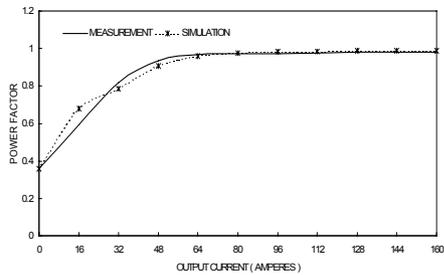


Figure 8. Power factor V.S. output current.

4 CONCLUSION

With strong ability of simulation of MATALB Simulink, parameters inside of circuitry of quadrupole DC power supply could be easily extracted without any laborious and dangerous work.

But the most important thing is that result obtained from simulation by MATALB Simulink is very good match to real performance, and based on this, any modification and research on circuitry of quadrupole DC power supply will proceed.

5 REFERENCES

- [1] Manual of Danfysik magnet power supply, system 8000, 1999.
- [2] Manual of MATLAB, 1999
- [3] Data book of LINEAR TECHNOLOGY, 1995.