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인버터의 선형 리액터 파라미터와 DC 버스 용량 계산

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Computations of Line Reactor Parameters and DC Bus Capacitance for Inverter

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Abstract - This paper proposes a novel analysis method for calculating inverter DC bus capacitance and line reactor parameters. In the realization process, DC bus capacitance parameter, and ripple current, life of DC bus capacitor, interaction between DC bus capacitance can be calculated by using Newton-Raphson procedure. The design scheme of DC bus capacitor and line reactor, specific parameters such as capacitance, loss, ripple current, central average temperature, life, ripple current, loss, size, central temperature of the reactor were given. Simulation results show that this scheme can accurately calculate the DC bus capacitance and line reactor parameters. Compared with calculation result of references, cost and volume are half. The indicators meet the demand of practical engineering. It had affirmed precision of the analytical method and verified correctness and feasibility of this method.

1. INTRODUCTION

In recent years, variable frequency AC speed control technology has gradually replaced the DC speed control systems due to its high speed control performance, significant energy-saving ability and wide suitability [1]. But due to factors such as nonlinear inverter itself, to produce a large number of harmonic, not only results in the decrease of local power electronics device life, power factor, but utilization rate of dc voltage is also reduced, and may harm the electric network and electric equipment.

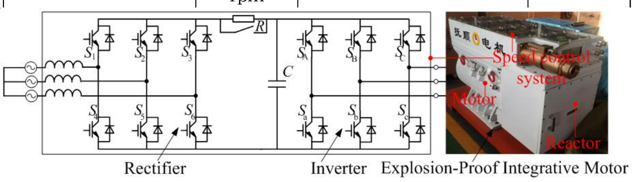
Based on this, this paper proposes a novel analysis method for calculating inverter DC bus capacitance and line reactor parameters, the capacitance value and sense of value calculation scheme, etc. In this paper, design of DC bus capacitance and line reactor and experience design value and experimental value are presented. Results show that the design of the bus capacitor and the line reactor, and the technical specifications meet the demand of inverter design which has reduces the cost.

2. SYSTEM SUMMARY

The parameters of the speed control system are shown in Table I, while the topology is shown in Fig. 1, including rectifier, current limiting circuit, bus capacitance, and DC-AC circuit.

<Table I> Parameters of the speed control system

Item	Value	Item	Value
Rated voltage	1140V	Maximum limited current multiple	2.5
Rated current	48.3A	Overload time	1 min
Rated power	75kW	Overload multiple	1.1
Rated speed	1478 rpm	Rated frequency	50 Hz



<Fig. 1> Topology of the speed control system

3. LINE REACTOR PARAMETERS ARE CALCULATED

The one phase voltage drop of line reactor is

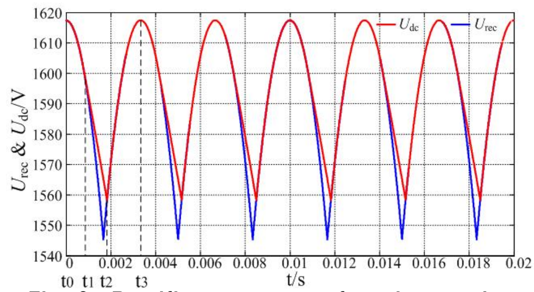
$$V_{AN}=\frac{V_N}{\sqrt{3}}=660\,V \tag{1}$$

Voltage drop of line reactor is 3% of one phase voltage drop in normal conditions. So voltage of line reactor can be expressed in (2).

$$V_L=\omega L I_N=3\%\,V_{AN}=19.8\,V \tag{2}$$

Where, ω is power angular frequency, L is inductance of line reactor, I_N is rated voltage of speed control system. Calculated $L=1.3mH$.

4. BUS CAPACITANCE PARAMETERS ARE CALCULATED



<Fig. 2> Rectifier output waveform in a cycle

The main purpose of the DC bus capacitor is to absorb the ripple current, and make the system output more stable in the inverter. When the value of DC bus capacitor is large enough, output voltage waveform of rectifier in a cycle is show in Fig.2.

Load power supply during t_0-t_3 is analyzed from which it can be obtained as

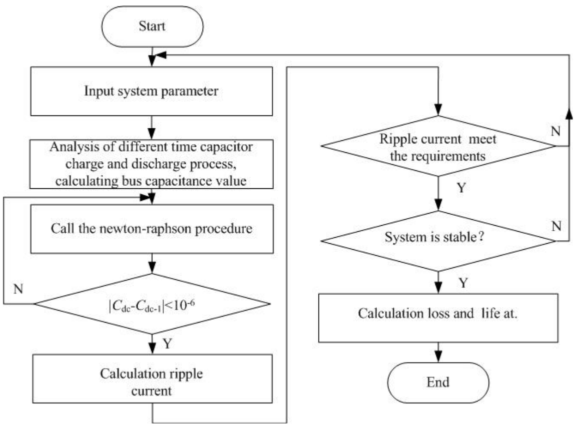
$$C_{DC}=\frac{P_{o\_dc}\left[\frac{\pi}{3}-\arccos(1-\alpha)\right]}{\omega U_N^2(2\alpha-\alpha^2)} \tag{3}$$

Where, C_{DC} is DC bus capacitance P_{o_dc} is output power of DC bus voltage, α is DC bus voltage drop percentage.

Loss, life, and current ripple can be calculated by the following formula.

$$\begin{cases} P_{C_{DC}}=I_{rc}^2 ESR \\ L=L_r 2^{\frac{T_0-T}{10}} K^{\frac{\Delta T_0-\Delta T}{10}} \\ I_{rc}=\sqrt{\left\{I_0\left[2M\sqrt{\frac{\sqrt{3}}{4\pi}+\cos^2\psi\left(\frac{\sqrt{3}}{\pi}-\frac{9}{16}M\right)}\right]\right\}^2+\left[\alpha\% C_{DC}\sqrt{2}\,U_N\sqrt{f_{c_s}\left(\frac{1}{t_c}+\frac{1}{t_f}\right)}\,\right]^2} \end{cases} \tag{4}$$

Where, ESR is equivalent series resistance of D bus capacitance, I_{rc} is ripple current, L_r is life working in rated current ripple and highest temperature, T_0 is maximum working temperature, T is actual working temperature, ΔT_0 is temperature rise under maximum working temperature, ΔT is actual center temperature rise, K is accelerated factor ripple current, f_{cs} is ripple frequency, t_c is charging time of DC bus capacitance, and t_d is discharging time of DC bus capacitance. Fig.3 shows the calculation process of DC bus capacitance based on the Newton-Raphson procedure.

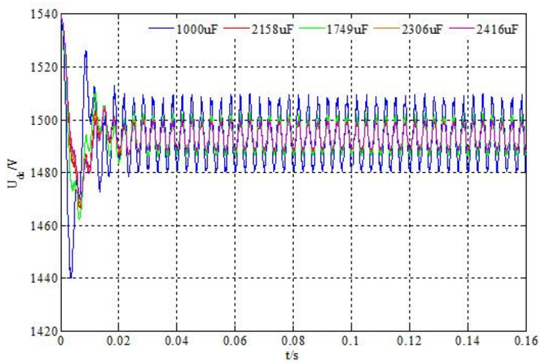


<Fig. 3> Diagram of DC bus capacitance calculation

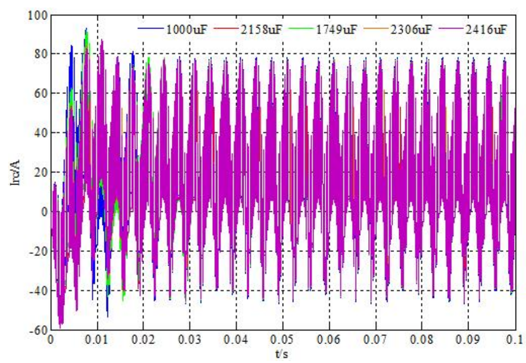
According to the principle of the above, value of DC bus capacitance can be determined is $946.24\mu F$.

5. SIMULATION OF LINE REACTOR AND DC BUS CAPACITANCE

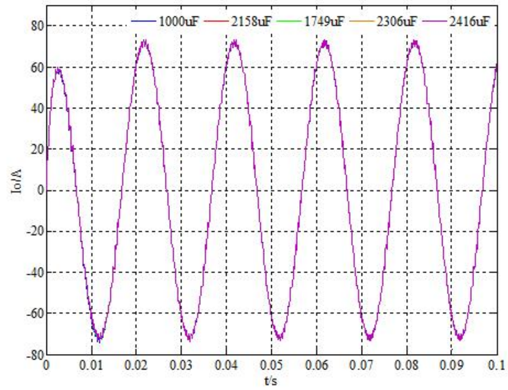
Fig.4 shows a DC bus voltage, Fig.5 shows ripple current of DC bus capacitance, and Fig.6 shows output current. Table II shows DC bus capacitance size with different calculation schemes, and Table III shows simulation results of line reactor and DC bus capacitance.



<Fig. 4> Waveform of DC bus voltage



<Fig. 5> Ripple current of DC bus voltage



<Fig. 6> Output current

<Table II> DC bus capacitance size with different calculation schemes

Scheme	value[μF]	Size[mm]	Cost[KRW]
This paper	946.24	325*350*120	50.6W
[2]	2158	325*350*230	111.4W
[3]	2306	325*350*240	114.1W
[4]	2416	325*350*240	115W

<Table III> Simulation results

Capacitance(uF)	1000	2158	1749	2306	2416
Voltage(V)	50.1	49.8	49.3	49.0	49.0
Ripple current(A)	25.9	25.6	25.3	25.1	25.1
Input current(A)	47.5	47.6	47.3	47.3	47.2
Output current(A)	50.8	50.8	50.8	50.8	50.8

As shown in Fig.4, Fig.5, and Fig.6 which propose calculation method and references[2]-[4] calculation value get DC bus voltage, ripple current of DC bus voltage, and output current is good output effect. Meanwhile as show in Table II and Table III that this paper calculates value on the premise that it can satisfy the system requirements compared with the calculated value of the literature, that cost and volume are half.

6. CONCLUSION

This paper proposes a novel analysis method for calculating inverter DC bus capacitance and line reactor parameters. And by using Newton-Raphson procedure DC bus capacitance parameter can be calculated. The value of DC bus capacitance, value of line reactor, ripple current, life, and loss can be detailed derived, The simulation results show that this scheme can accurately calculate the DC bus capacitance and line reactor parameters. Compared with calculation result of references[2]-[4], that cost and volume are half. The indicators meet the demand of practical engineering.

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[References]

[1]J. J. Patel, A. M. Kubavat, and M. B. Jhala." Speed control of a three phase induction motor using PWM inverter," International Journal of Engineering Development and Research. vol. 2, no.1, pp. 503-507, 2014.

[2] Chang Donglai.The calculation of Ripple Current of DC Link Capacitors in Variable Frequency Driver. THE WORLD OF INVERTERS. vol. 2, pp.50-52, 2010.

[3] Liu Haitao, Chentao.Calculation and Analysis of DC Link Capacitor's Current for AC-DC-AC Inverter.HIGH POWER CONVERTER TECHNOLOGY. vol.4, pp. 5-9, 2014.

[4] Qu Taiyuan.Design and Study on 250kVA Three Level Middle Voltage Inverter.Beijing:Beijing Jiaotong University.