Electromagnetic interference analysis and measures of the antenna servo system of ship-borne satellite communication

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Abstract. This paper analyzes the working principle of servo drive, introduces the interference source of electromagnetic interference, and summarizes the damage caused by electromagnetic interference. Based on the characteristics of the ship's electromagnetic environment, the suppression measures of the electromagnetic interference of the ship servo drive are proposed.

Keywords: Ship; Servo drive; Electromagnetic interference; Filter.

1. Introduction

The antenna servo system of ship-borne satellite communication is the pivotal equipment of ship-borne communications, The high-power diode's commutation and high-power transistor's invert in servo drivers can produce a large number of electromagnetic interference in the input and output circuit, the interference will not only interfere with the microcomputer control system of communications control cabinets, but also along the power transmission to the power grid, pollution of the whole power supply network, through the space radiation coupling interference adjacent equipment and damage of the servo motor.

2. The cause and damage of electromagnetic interference

2.1 The cause of electromagnetic interference

The servo drive, like the inverter, has an 'alternating current- direct current- alternating current ' circuit structure in the working circuit, the three-phase alternating current power supply is changed into direct current by the three-phase rectifier bridge and filter capacitor, and then converted into the alternating current with adjustable frequency by the control circuit and inverter pipe. The harmonic generated by the rectifier diode used in the servo driver and the thyristor (IGBT: Insulated Gate Bipolar Transistor) used in the inverter is the source of electromagnetic interference. The "alternating current(AC)- direct current(DC)- alternating current(AC)" circuit structure of the servo driver is shown in Figure 1 [1]

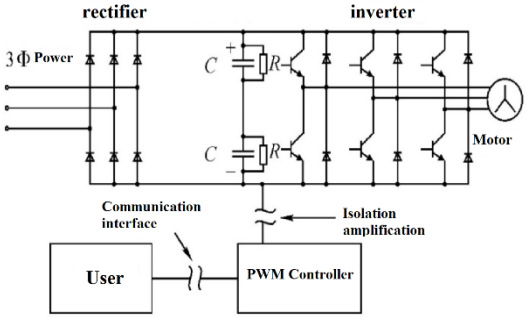


Fig. 1 The "alternating current- direct current- alternating current" circuit structure.

The electromagnetic interference generated by the servo driver is shown in the following aspects

1) dv/dt .At the on-off moment of rectifier tube, thyristor and other power electronic devices, the voltage jump will produce a large charging or discharging current on the capacitor. Therefore, the

control circuit in the servo driver scattered capacitance, will produce large current transient pulse, bring serious electromagnetic interference.

2) the di /dt. The current change of the switch device in the transient is induced by the stray inductance, and the large current loop is also a source of radiation, which will generate radiation electromagnetic fields for the space.

3) The PWM signal. In addition to the useful fundamental wave, the PWM waveform generated by the switch in the inverter also contains a large number of high harmonics. Because of the existence of high harmonics, The PWM signal will also have a radiation effect on the surrounding equipment.

4) Waveform of input current. The input side of inverter in servo driver is diode rectifier and capacitor filter circuit. The charging current always appears near the amplitude of the power supply voltage, in the form of discontinuous shock wave, with strong high-order harmonic components.

2.2 The damage of electromagnetic interference

As a strong electromagnetic interference source, the servo driver will not only cause electromagnetic interference to the external power grid and adjacent equipment through cable conduction and space radiation coupling, but also cause a serious interference in the control circuit of the servo driver itself, affecting the stability of the driver. The damage of electromagnetic interference caused by the antenna servo system of ship-borne satellite communication mainly includes the following aspects:

1) Additional copper and iron consumption is generated in the elements of the onboard power supply network, which reduces the efficiency of power generation, transmission and electric equipment.

2) Reduce the insulation of servo motor, shorten the life of the motor and even damage. In the ship radar antenna servo system, the connection cable between the servo and servo driver is long, and the high pulse voltage generated by the inverter circuit will generate traveling wave voltage reflection through the long cable transmission, which will produce overvoltage phenomenon at the motor terminal. Overshoot voltage produces peak current in the motor windings, which causes overheating in the uneven insulation layer of the motor windings, and even burns the insulation layer, resulting in damage [4].

3) The signal acquisition and transmission errors affecting the sensor circuit make the measurement of the electrical measuring instrument inaccurate or cause the automatic protection device to misoperate.

4) Increase the background electromagnetic noise inside the ship, reduce the receiving sensitivity of communication equipment such as SATCOM communication receiver and radio receiver, reduce the communication quality, or even lead to information loss, so that the communication system cannot work normally.

3. Analysis of electromagnetic interference suppression measures

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3.1 Analysis of general electromagnetic interference suppression measures

Electromagnetic interference sources emit electromagnetic interference energy and couple the interference energy to sensitive devices through the coupling path, which interferes the work of sensitive devices. This process is called electromagnetic interference effect. According to the

mechanism of electromagnetic interference, electromagnetic interference must have three basic elements, as shown in Figure 2:

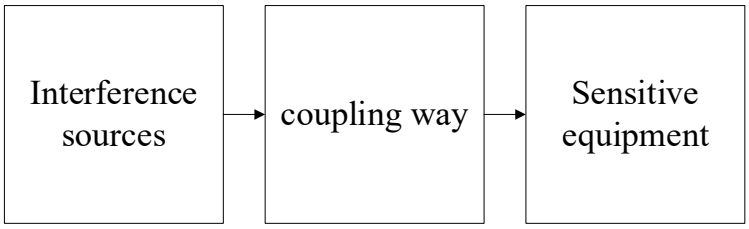


Fig. 2 Three elements of electromagnetic interference.

Based on the three elements of electromagnetic interference, the universal measures to suppress electromagnetic interference are as follows:

1) Filtering: filtering mainly uses passive devices such as inductance, capacitance and magnetic beads to reduce the interference value of the interference source by reflecting, draining and absorbing the interference source;

2) shielding: the method of shielding is to cut off the interference coupling path to control electromagnetic interference. On the one hand, the shielding can limit the interference source to a certain area without external emission, on the other hand, it can also protect sensitive equipment from external electromagnetic interference;

3) grounding: grounding can introduce interference source to the earth, restrain the influence of external electromagnetic interference on electronic equipment, reasonable grounding in the circuit can also reduce the electromagnetic interference caused by the earth elastic noise to affect other electronic equipment;

4) Isolation: a reasonable layout of equipment and wires and cables, on the one hand, can separate the interference source and sensitive equipment, reduce the coupling efficiency of the two, on the other hand, reduce the interference signal coupling to the ground loop, affecting the interference suppression effect of grounding.

3.2 Analysis of electromagnetic interference suppression measures of ship servo Driver

There are essential differences between the electromagnetic environment of electronic equipment on board and the magnetotelluric environment: the earth, as a good conductor full of infinite negative charge, can absorb a large amount of interference current without affecting the voltage of the reference ground or introducing interference current to other electronic equipment through the earth; The reference "ground" of the ship is a metal hull, and the interference current introduced to the "ground" of the hull will flow in the "ground" circuit of the hull. If the interference of the "ground" circuit is not properly handled, it will be introduced to other electronic equipment or increase the sensitivity of the sensitive equipment through the "ground" of the hull, and the sensitivity of the reference ground noise will be reduced. Therefore, when using filtering, shielding, grounding and isolation measures to deal with the electromagnetic interference of the ship servo driver, the interference suppression measures with electromagnetic absorption should be adopted first, and the measures of introducing the interference into the hull ground should be avoided as much as possible.

4. Passive filter electromagnetic interference suppression measures

4.1 Input filter

A The input filter of servo driver can not only filter the interference from servo driver to the power grid, but also block the harmonic interference from the power grid to the servo driver. EMI conducted interference is divided into common mode interference and differential mode interference: common mode interference is the noise interference between phase line/middle line and ground line; Differential mode interference is the noise interference between phase line and middle line. Common

mode inductance and capacitance are used to suppress common mode interference while differential mode inductance and capacitance are used to eliminate differential mode interference. The principle of inductance to eliminate interference is to reflect the interference voltage back to the interference source, while capacitance is to introduce interference to the ground or drainage back to the interference source. For shipborne electronic equipment, interference should be avoided as far as possible to the hull reference point. Gjb151a-1997 electromagnetic emission and sensitivity requirements for military electronic equipment and subsystems clearly stipulates that for equipment with 400Hz power supply, the filter capacitor between phase line and ground line should be less than 0. 02μF.The typical filter circuit structure is shown in FIG. 3. Input filter design can refer to La=2mH, C1=2μF, Lb=30μH to select parameters.

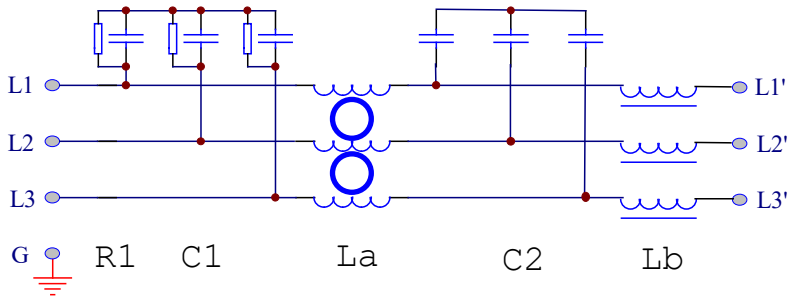


Fig. 3 The Input filter circuit structure.

4.2 Output filter

Differential mode capacitor cannot be connected to the output filter of the servo driver near the servo driver, because when the IGBT of the inverter circuit is on/off, a large peak charging/discharging current is generated between the phase circuits, which may damage the IGBT of the inverter tube.

Therefore, differential mode capacitance is generally not used in the design of output filter, and its typical circuit structure is shown in Figure 4:

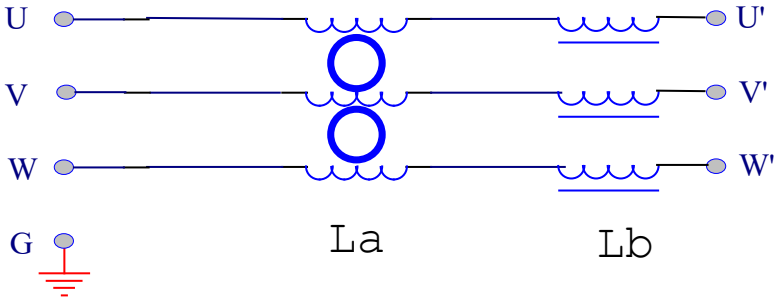


Fig. 4 The Circuit structure of output filter

The differential mode inductance parameters in the output filter should be selected according to that the voltage drop of the fundamental current flowing through the output filter is about 4% of the rated voltage. Fig. 4 shows the relationship between harmonic suppression and voltage drop.

	0.5%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
5th	80	60	46	40	34	32	30	28	26	24	23
7th	60	37	22	16	13	12	11	10	9	8.3	7.5
11th	18	12	9	7.3	6.3	5.8	5.2	5	4.3	4.2	4
13th	10	7.5	5.8	4.9	4.2	3.9	3.6	3.3	3.15	3	2.8
17th	7.3	5.2	3.6	3	2.4	2.2	2.1	0.9	0.7	0.5	0.4
19th	6	4.2	2.8	2.2	2	0.8	0.7	0.4	0.3	0.25	0.2
%THID	102.5	72.2	52.3	44.13	37.31	34.96	32.65	30.35	28.04	25.92	24.68

Fig. 5 Relationship between harmonic suppression and voltage drop

4.3 the used of Input/output filter

In order to better play the filtering effect of filter, two points should be paid attention to when the servo driver input/output filter is installed and used: 1) ensure that the input line and output line of filter are separated. If the input and input lines of the filter are tied together or installed too close to each other, the high-frequency attenuation of the filter may be reduced due to their coupling.2) Input/output filters shall be installed on both sides of the servo driver as close as possible.

5. Other Electromagnetic interference suppression measures

The servo driver input and output filters cannot completely eliminate the strong electromagnetic interference generated by the servo driver. The following measures should be taken according to the actual situation of the project:

1) In the control cabinet, the servo driver and other low-voltage digital control circuits should be rationally arranged. The servo drive is generally placed at the bottom of the cabinet, and the low voltage digital control circuit is as much as possible based on the servo drive. At the same time, the power cable of the servo driver and the communication cable of the low-voltage digital control circuit should be divided into two independent troughs. For some key communication cables, anti-electromagnetic interference measures can be taken such as installing signal filters and ferrite absorbing magnetic clips separately.

2) The power cable between the servo driver and the motor shall be shielded, and the shielded layer shall be connected to the aviation plug 360 degrees to ensure good electrical continuity;

3) Cannot blindly grounding, must not interfere with large power cable shielding ground and low voltage digital signal ground access to the same hull ground, can use multi-point grounding.

6. Conclusion

By analyzing the working principle of servo driver and the mechanism of electromagnetic interference, the harm caused by electromagnetic interference is summarized. Based on the characteristics of ship electromagnetic environment, the countermeasures of electromagnetic interference suppression of ship servo driver are proposed. The electromagnetic interference of servo drive involves the knowledge of many subjects. When dealing with practical engineering problems, the electromagnetic interference measures should be taken in combination with the field engineering environment.

References

[1] Zhu Yutang, XU Li, Electromagnetic compatibility and suppression of frequency converter [J]. Mechanical and electrical engineering, 22(5)40: 44, 2005.

[2] PEI Xuejun, Research on Conducting Electromagnetic Interference of PWM Inverter [D]. Wuhan, Huazhong University of Science and Technology, 1-122. 2004.

[3] Zhang Liuyi, Interference Sources and Anti-interference Measures in the Process of Frequency Converter [J]. Metallurgical Series, 2: 12-15, 2007.

[4] Zhang Xiaopeng, Application of Electromagnetic Compatibility technology in Frequency Converter [J]. Automation Expo.