A Design and Simulation Study of Airborne External Lights System

Qunmin YAN

School of Electrical Engineering, Shaanxi Sci-Tech University, Hanzhong, Shaanxi, 723000, China

Abstract **— Aircraft exterior light signals give the position and direction of the plane, which also helps to maintain contact between plane and ground staff. In order to develop a practical new type of aircraft exterior lights system, we use the LM555 chip as the main element in this paper and design the light system hardware circuit and protection circuit and verify it by simulation experiments. The result shows that the circuit is implemented successfully and protection circuit conform to the requirements of the system.**

Keywords - External Lighting, LM555, Saber, Simulation Study, Function

I. INTRODUCTION

Lighting system can be divided into the Interior lighting and external illumination as an important subsystem of the plane.The Interior lighting Provides comfortable lighting environment for those on board. The external illumination mainly includes the landing lighting and external light signal,which is one of the indispensable conditions when the plane fly in the night or complex weather conditions[1-2]. The landing lighting, combined with the the ground lighting control system which based on the I- BUS or c - BUS electrical installation[3-4], is widespread use of landing lights, taxi lights or glide landing lights. External illumination is used to mark the plane position and direction of motion, and as a contact signal between aircraft and aircraft or aircraft and ground[5].It is very important that designing a set of safe, reliable, efficient and practical aircraft exterior lighting system circuit,which should also meet the requirements of small volume, light weight, low power requirements, etc,because it related to the aircraft flight safety[6-7]. The lighting system In this pape,as the LM555 chip as the key, exterior lighting system hardware circuit and Protection circuit of Aircraft has been designed and taken to the simulation experiment with the saber. The last Result shows that the circuit can be a very good implementation,which can be required by the corresponding function of Exterior lighting system, and Protection circuit conform to the requirements of the system.It has a certain reference significance for the system.

II. SYSTEM ANALYSIS

A. Modeling analysis of external lighting system

There is a total of 4 working conditions for external lighting system, which is "Bright" "Dark" "Lightning" and "Off".The Four through relay has the effect of control and isolation in the automatic control circuit. Relay through low voltage and low current controls the automatic switch. "Bright" or "Dark" is based on continuous or without electricity. "Lightning" or "Off" is based on the integrated circuit with FX555 time-base circuit.

There are two working conditions in the FX555 chip, which is steady-state operation mode or not.The steady-state operation mode has the function of the Schmitt trigger and monostable trigger.The no steady-state operation mode refers to the not-fixed mode.The FX555 time-base circuit is in the condition between the alternate and repeated setting,which outputs high level and low level alternately as a result. The output waveform approximation is the rectangular wave[9]. The no steady-state operation mode also called the self-exciting multivibrator because Higher harmonic of the rectangular wave.The basic circuit diagram is shown in figure 1.

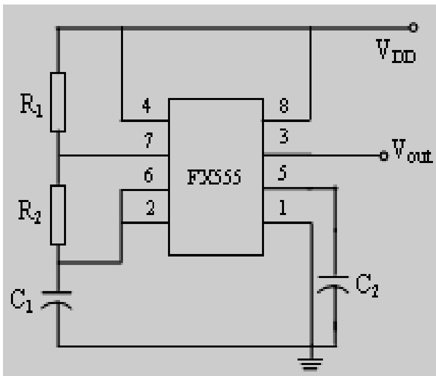

Fig.1 The basic circuit diagram of the no steady state operation mode for the FX555

Firstly, 2 feet is low level and 3 feet is high level because both ends of the capacitor C_1 voltage.The voltage rises because internal discharge transistor is cut-off and 7 feet is suspended .After t1 ,the voltage(6 feet) Levels to 2/3 V. FX555 time-base circuit reset from Table 1. 3 feet is low level and 7 feet is also low level because internal discharge transistor is conduction. The C_1 discharges

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through R_2 to 7 feet and the voltage of 6 feet falls increasingly. After t_1 ,the voltage Levels to 1/3 V and 3 feet is high level.As a result, C_1 is in a state of charge and discharge constantly and 3 feet will output high level and low level alternatly in circle.

TABLE1. THE TRUTH TABLE OF 555 TIME BASE CIRCUIT

Pins	Low trigger (2 Pin)	High trigger (6 Pin)	Compulsory reduction (4Pin)	Output (3 Pin)	Discharge (7 Pin)
Level High Low	≦V/3	Arbitrary	High	High	Hang
	>V/3	≧2V/3	High	Low	Low
	>V/3	<2V/3	High	Keep	Same 3pin
	Arbitrary	Arbitrary	Low	Low	Low

When 3 feet is high level ,t_1(Charging time)is

$$t_1 = -(R_1 + R_2)C_1 \ln[(V - 2/3V)/(V - 1/3V)] = (R_1 + R_2)C_1 \ln 2 \approx 0.693(R_1 + R_2)C_1 \quad (1)$$

When 3 feet is low level ,t2(Discharge time)is

$$t_2 = 0.693R_2C_1 \quad (2)$$

Repeated oscillation cycle T is

$$T = t_1 + t_2 = 0.693(R_1 + 2R_2)C_1 \quad (3)$$

Oscillation frequency f is

$$f = 1/T \approx 1.44/(R_1 + 2R_2)C_1 \quad (4)$$

The output pulse duty ratio D is

$$D = t_1/T = (R_1 + R_2)/(R_1 + 2R_2) \quad (5)$$

When R2>>R1,D is about 50%.The output waveform is ideal and symmetrical square wave.

External lighting circuit design which based on the FX555 are shown in figure 2 .

The D, C, E, F are from the power supply manager.Each controls "Bright" "Dark" "Lightning" and "Off".

In fact, there is a Pull-up resistor about 1kΩbetween the anode and 3 feet. It can make the voltage value closed to V when 3 feet is high level. Semiconductor triode which connected to lighting load can lead to the light flashing when outputing high level or low level alternatly. That's "Dark".

the same in the simulation model.The differences in them is frequency.The frequency of "Dark" is 600Hz and of "Lightning" is 1500Hz[10].Changing C1 and R1 and R2, the output pulse duty ratio D is changing. Realization of frequency change is depends on zhe t1 and t2.

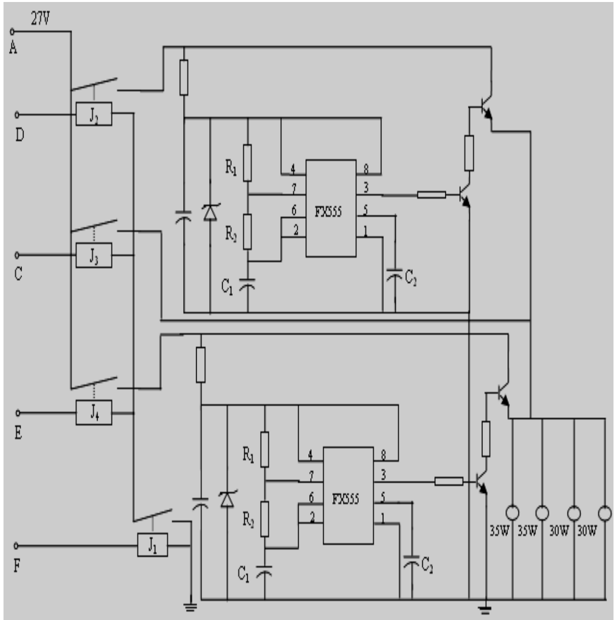


Fig. 2 Exterior lighting system circuit diagram

B. The over-current protection device modeling

In accordance with the requirements of military targets ,aircraft over-current protection function is to be achieved: when the load within the rated range, the power should continue to load ; When the load at the rated load and less than 1.5 times the rated load , the power supply should be continued for 5 minutes to load. When the load at 1.5 times the rated load and less than 2 times the rated load ,the power supply should be continued for 5 seconds to load. Load greater than 2 times rated load ,the supply to load should immediately cut off power supply .Overcurrent protection schematic shown in Figure 3.

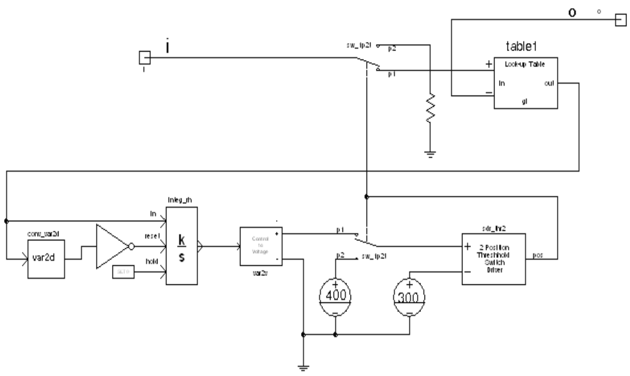


Fig.3 Over-current protection circuit model

Mainly by the over-current protection: current TUL lookup module, integration module and the switching time compared execting agencies. Over-current protection circuit to boost an example , Figure 3 of the table 1 namely TLU table for current ,its setting as shown in figure 4 shows.

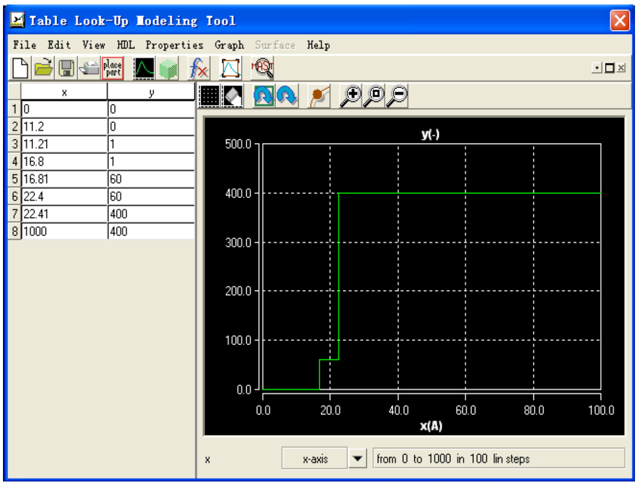


Fig. 4 The over current protection TLU table

If the total power of the DC converter for 700W, Boost the output voltage of the module is constant 27V, Therefore ,Rated current is 25.9A. Form on the left of the variable X is the size range of current value. The right of the variable Y is Time integration module described by the following formula:

$$K\int_0^t \partial t = 300 \qquad (6)$$

In the formula: K is TLU table for the corresponding current output control corresponding to the amount of size , That is to say , the size of the Y values.

When the current within the rated current, the system output controls quantity is 0, the time integral module starts points and the result is 0, compared with the switch action quantity 300,the switch state control quantity is 1, this time the switch is normally in closed state, namely the power source has given the steering gear power supply ;When the current in the rated current and 1.5 times rated current range, the system output controls quantity is 1, the time integral module starts points, when the integral results more than 300, the switch state control quantity becomes 2,the switch separates, namely the power source stop giving the steering gear power supply ;Due to the time integral module has been integral to 300 before the switch separates, in the saber it equals to 300 seconds of integration time ,this implements the function of giving load power supply continually 5 minutes when the load in the rated load and 1.5 times rated load range.

C. System protection control

For the protection of the control model , Its composition is the logic element of Saber and MAST language model . Detecting the specified signal determine and implement logic of self-control operations,such as the main power of the over-voltage protection control model .When the detected voltage vaule of the main bus bars relative to the value of the forward cross v_over . The control model outputs two control signals . It is discrete switch driven signal POS and digital pulse signal d. used to isolate the engine power model ,control battery model input . Control signal output model can be MAST language modeling, the sin model template shown in Figure 5 .

```
template power_ctrl   p m pos d=v_over, pw
electrical   p, m
state nu pos
state logic_4   d
number v_over=undef , pw=undef
{   val v v
    values{
    v=v(p)-v(m)
    }
 when (dc_init) {
      schedule_event(time , d , l4_0)
      schedule_event(time , pos, 1 )
 }
 when (time_init  | threshold(v, v_over))
  {   if(v>=v_over){
      schedule_event(time,pos,2)
      schedule_event(time,d,l4_1)
      schedule_event(time+pw,d,l4_0)
  }
```

Fig.5 sin control signal output model template

Figure 5 shows the template, the template established package model has two inputs p, m, for the detection of a given voltage, the comparative judgments after the two output pos, d output control signals.

III. SYSTEM ANALYSIS

A.The results of simulation analysis

The simulation parameter in "Dark" is:

$R_1 = 430k\Omega, R_2 = 190k\Omega$, $C_1 = 3300pF$, $C_2 = 0.01uF$ with saber. And in "Lightning" is $R_1=18k\Omega$ 、 $R_2=151k\Omega, C_1=0.022uF, C_2=0.01uF$. The voltage waveform is shown in figure 6 and 7.

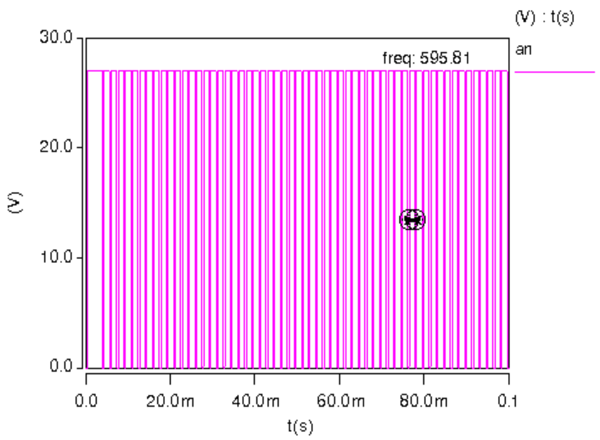


Fig. 6 External light dark when Dar

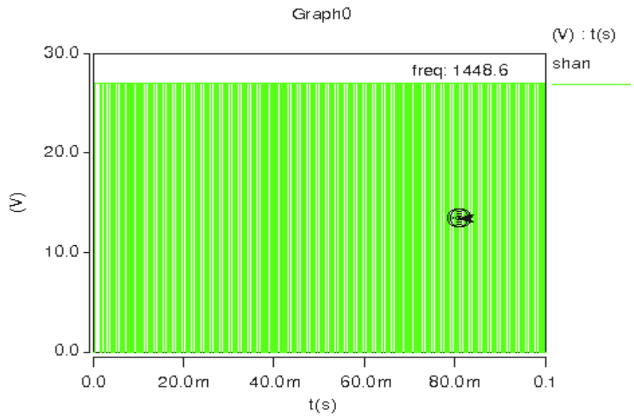
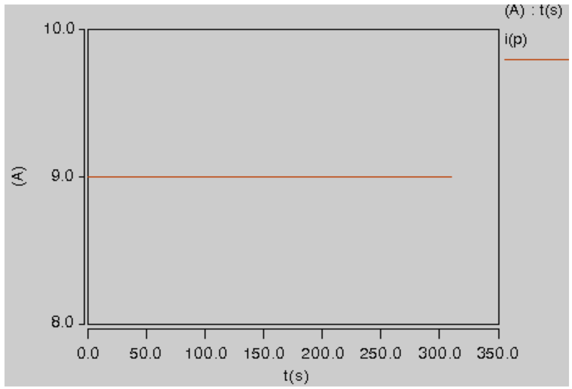


Fig.7 External light dark when Lightning

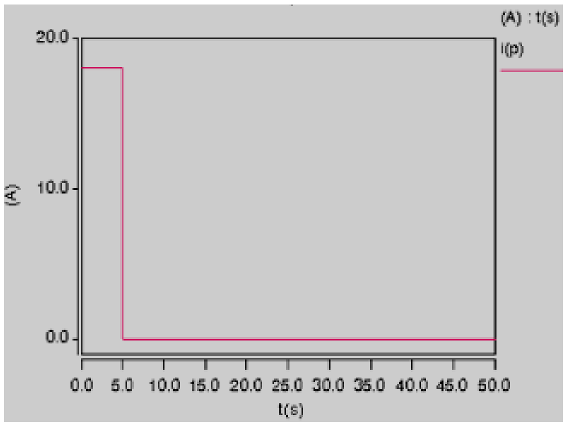
The hardware system design can be achieved to "Dark" and "Lightning" In the analysis. The light frequency can meet the system requirements

B. Simulation and analysis of over-current protection

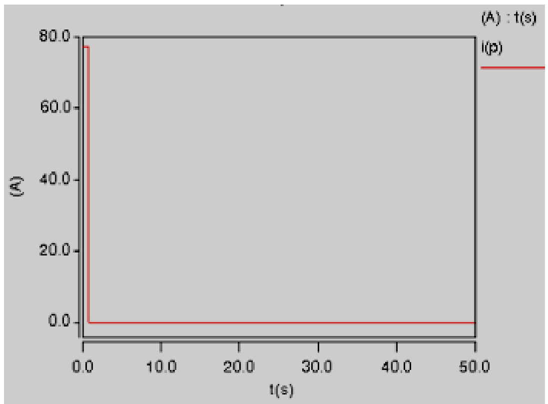
Over-current protection requirements of functionality mentioned above, the load at the rated load, respectively, and 1.5 times the rated load, between 1.5 and 2 times the rated load and rated load 2 times the rated load between the three cases above simulation, The simulation results are shown in Figure 8.



a . current curve of 0.7 times rated load



b. current curve of 1.7 times rated load



c. current curve of 10 times rated load

Fig.8 The current curve of different loads

C. Over-voltage simulation and analysis

In the simulation before the artificial mains overvoltage, when the system power supply voltage higher than 32V, the power control system cut off the main power supply, And the main power from the batteries in parallel electrical equipment important to continue to supply the load. Set the main power supply system shown in Figure 9, after the main power supply output voltage over-voltage waveform shown in Figure 10.

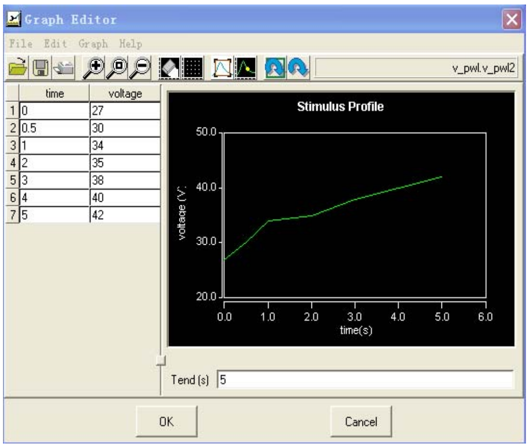


Fig. 9 Main power supply voltage setting table

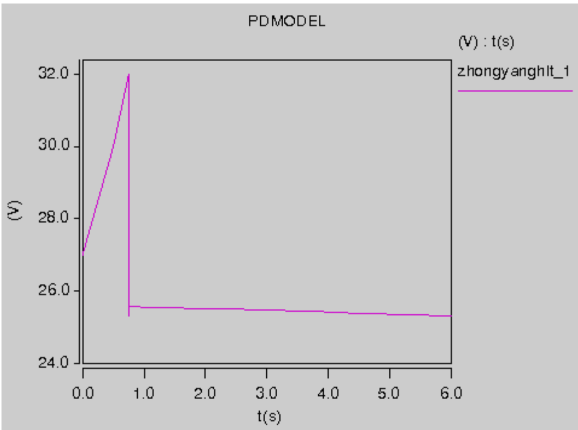


Fig.10 Main power overvoltage output voltage wave

The simulation results from the above can be seen in 0.7 seconds, the system main power to 32V, the main power supply voltage protection system will cut off the main power. Then change the battery to power the system.

IV. CONCLUSIONS

Lighting system is an important subsystem of the plane. especially the external illumination mainly is one of the indispensable conditions when the plane fly in the night or complex weather conditions. External illumination a contact signal between aircraft and aircraft or aircraft and ground.It is very important that designing a set of safe, reliable, efficient and practical aircraft exterior lighting system circuit,which should also meet the requirements of small volume, light weight, low power requirements, etc,because it related to the aircraft flight safety. The lighting system In this pape,as the LM555 chip as the key, exterior lighting system hardware circuit and Protection circuit of Aircraft has been designed and taken to the simulation experiment with the saber. The last Result shows that the circuit can be a very good implementation,which can be required by the corresponding function of Exterior lighting system,and Protection circuit conform to the requirements of the system.It has a certain reference significance for the system.

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