A type of trigger system for electromagnetic rail gun

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***Abstract*—In this paper, a type of trigger system for electromagnetic rail gun was reported. The power supply of Electromagnetic-launch-system was achieved by pulse discharging of capacitor, it had the characteristic of high voltage and huge current, so a reliable measure-and-control system was necessary to avoid the danger and to insure the predetermined power supply touching off according to the predetermined time sequence. We use serial communication for its characteristic of low cost and easy maintenance, and transmitted signals by optical fiber between master computer and terminal because of the very strong electromagnetism disturbing. The trigger in power supply employed synchronous optical coupling technique and transformer isolation drive to insure touch off safely and anti-interference ability.**

Keywords: rail gun; serial communication; trigger

I. INTRODUCTION

Electromagnetic-launch-system was the setup which could transform electromagnetic energy of power supply to the kinetic energy of object, generally it was made up of energy system, measure-and-control system and launching device. The original energy of Electromagnetic rail gun was achieved by pulse discharging of capacitor, in our tester, discharging voltage could higher than 10KV, and discharging current could reach 700KA, so a credible trigger was necessary to avoid the danger and to insure the predetermined power supply touching off according to the predetermined time sequence.

II. SYSTEM DESCRIPTION

Our electromagnetic rail gun included 32 power supply, total energy was 3.2MJ, the scale of our tester would extended to 10 MJ in the near future, the tester was made up of power supply, charging device, trigger, measure and control system, B dot detector. Power supply were placed in one room, other systems were place in another room faraway power supply. The structure sketch of our tester was shown in Fig.1

Before we decided communication method, the message exchange features of electromagnetic rail gun tester must be analyzed first.

1. Strong electromagnetic disturbing.

2. Communication object was asymmetric: Master computer sent control instruction, the MCU within power supply carried out the order; ascending-descending transmit speed and transmit mode were different.

3. Communication object scattered, power supply was placed on different bracket, the scale of energy could enlarge to 10MJ.

4. As a pilot system, communication method required simple, reliable, easy maintenance, low cost.

5. Data size of message exchange was small, exchange frequency was low. The triggering command included only 16 characters, and only when power supply was touching off, the communication link was used.

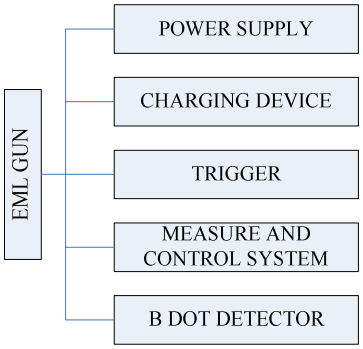

Fig.1 Structure sketch of electromagnetic rail gun

Secondly, we analyzed the mainly data communication ways in digital control:

1. Bus-master. The two computer's bus connected each others with a buffer converter, this way was used only in the same or the series computers, scope of application was narrow, communication, distance was short;

2. Modulation / demodulation. Using serial port, output data passed through parallel-to-serial converter and was modulated before transmitted in the dual-core line. The signal was to be demodulated and serial-to-parallel conversion, than recovered the original data. This approach could connected any modulation / demodulation device with same communication speed, and had a wide range of applicability, its communication distance reached a few kilometers away from, but the communication speed was not high, (typically only a few thousand baud), information transmission capacity could not be too much, suitable for occasions where data communication was not frequent.

3. High-speed data communication connection. It was widely used in currently distributed control system. Actually it used coaxial cable with high-speed communications capabilities. This means of communication had the advantage of high transmit

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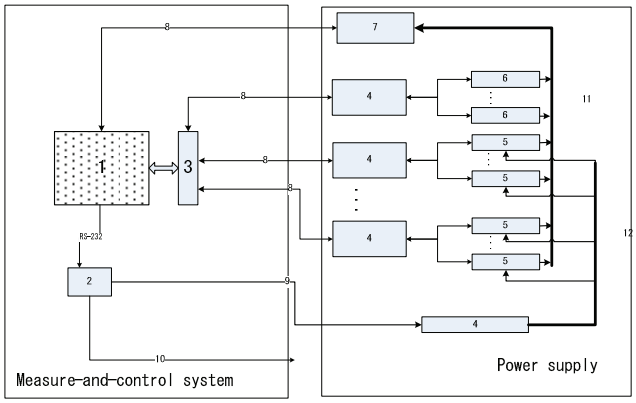
speed, long transmission distance, wiring simple, good versatility, extended easily.

Based on factors mentioned above, we designed the measure-and-trigger system which schematic diagram was shown in Fig.2, (for simple operations, measure-and-trigger system was integrated into one master computer).



1. Master computer 2.Trigger signal generator

3. Multi-serial port extending card

4. Optical fiber coupler 5.Pulse power unit

6. Charging device 7.Module of voltage measure

8. Optical fiber RS-232 9.Trigger optical signal

10. Trigger signal for synchronous measure

11. Voltage signal 12.Discharging signal

Fig 2.Schematic diagram of measure-and-control system

As shown, master computer connected trigger signal generator with a cable via serial port, Trigger signal generator received the discharge timing configuration commands, as well as discharge command, touched off the entire power supply, Serial communications signals will be converted into optical signals using optical transceiver module, transmitted through the optical fiber. In the course of transmission, the optical signal was separated into multi-channel optical signals with the fiber optic coupler, thereby reduced the number of cables, in the module terminal , SCR trigger received optical signals to control power supply triggering.

III. Development of Trigger Signal Generator:

1. Discharge timing options

The power supply discharged with some predetermined time sequence, so that the energy was put into delivery system in batches, it could ensured that there was always the existence of thrust force during the armature moving along the guide, as well as reduced the maximum current to prevent heat capacity overproof, the next picture showed current simulation under the situation of charging voltage 8000v, dividing 32 power supply into 12 section, you can see in this conditions, the discharge current platform 500KA, platform width of 2.5ms, the platform current fluctuation does not exceed 6%, meeting test requirements. Therefore, we chose discharging sequence as 12.

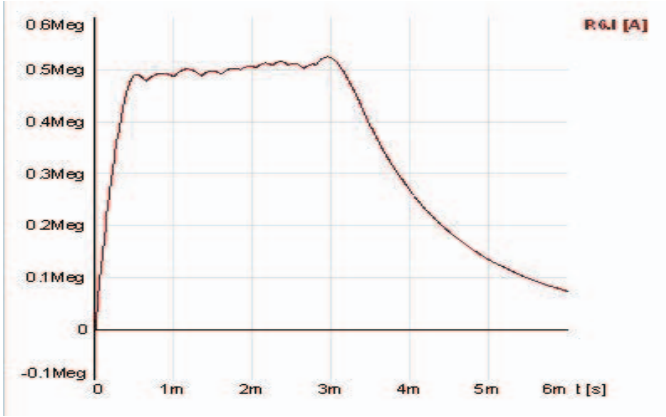


Figure 3 Simulation diagram of the discharge current waveform

2 Photoelectric match characteristics research

We use a company's phototube as the electro-optical detection components of the trigger within power supply, and the same company's light-emitting devices of same wavelength, does not meet the requirements for its small output power.

Therefore, to research optical matching feature between trigger source and electro-optical detection components of the trigger within power supply was necessary.

In the experiment, we chose two different wavelength semiconductor lasers, use the actual application of the same optical transmission, control scheme, that was, use the same fiber optic splitter to control thyristor trigger. Through the research of response voltage, drive current, response delay to determine the reasonable semiconductor laser's wavelength and output power.

Two different wavelength lasers were put to test in condition of different output power, experiment result were shown in Fig.4 and Fig.5. It could been seen from Fig.4 more greater the power, more shorter the time delay, and there had the best matching conditions. It could been from Figure 5, for different power input, response of trigger appeared oscillation phenomenon, the output drive current appeared intermittent phenomenon, it stated that the semiconductor laser's wavelength was not match optoelectronic devices of trigger.

Thus we decided to select the corresponding semiconductor laser as light source of trigger.

In the design of trigger signal generator, control core was FPGA, serial interface, timing pulse signal generation circuit were integrated into one, it could achieve the following functions and performance:

1.Communicated with host master and set up working condition of FPGA, and accepted the instructions of host computer, returned the results.

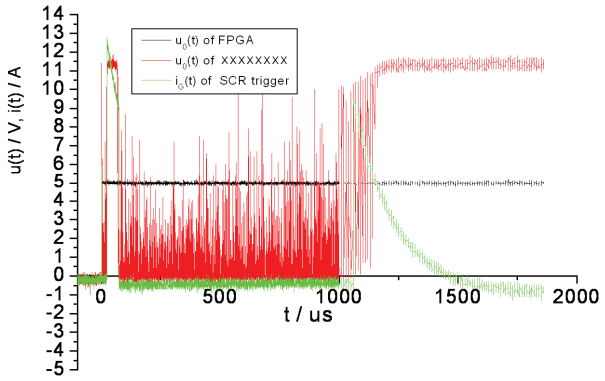


Fig. 4 Laser output and optical receiver circuit response voltage

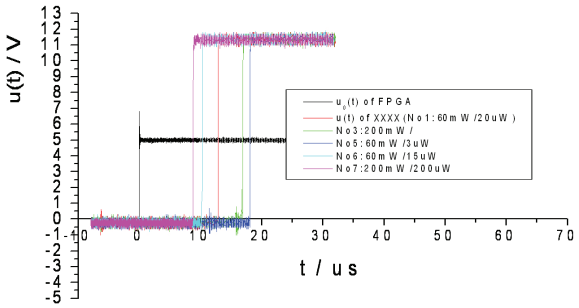


Fig.5 Laser output and optical receiver circuit response voltage

2.Complete the 12-pulse timing signal configuration, trigger time precision error was less than 500ns, each 2-way adjustable trigger pulse interval was N × 500ns (N is an integer), every ways pulse width can be individually configured, Pulse width adjustment ranged from 50ms to 1s, also supported long time trigger.

The trigger signal generator was shown below

Fig.6 trigger signal generator

The trigger in power supply employed synchronous optical coupling technique and transformer isolation drive to insure touch off safely and anti-interference ability. It was shown below.

Fig.7 Trigger in power supply

IV. CONCLUSION

On the basis of analyzing the electromagnetic guns work environment characteristics and trigger communications features as well as the SCR trigger photoelectric characteristics of our electromagnetic launch system ,we developed a trigger system, using serial communication, connect the trigger signal devices and power supply with optical fiber, use semiconductor laser as a trigger light source, the system can triggered determined power supply according to the determined timing sequence, to get pre-discharge current, and can effectively avoid the strong electromagnetic interference of capacitive discharge , in actual experiments, stable Reliable.

ACKNOWLEDGMENT

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