BNL-94140-2011-CP

A real time status monitor for transistor bank driver power limit resistor in boost injection kicker power supply

J. Mi, Y. Tan, W. Zhang

Presented at the 2011 Particle Accelerator Conference (PAC'11)
New York, N.Y.
March 28 – April 1, 2011

Collider-Accelerator Department

Brookhaven National Laboratory

U.S. Department of Energy
Office of Science

DISCLAIMER

A REAL TIME STATUS MONITOR FOR TRANSISTOR BANK DRIVER POWER LIMIT RESISTOR IN BOOST INJECTION KICKER POWER SUPPLY *

Jianlin Mi, Y. Tan, W. Zhang

BNL, Upton, NY 11953, USA

Abstract

For years suffering of Booster Injection Kicker transistor bank driver regulator troubleshooting, a new real time monitor system has been developed. A simple and floating circuit has been designed and tested. This circuit monitor system can monitor the driver regulator power limit resistor status in real time and warn machine operator if the power limit resistor changes values. This paper will mainly introduce the power supply and the new designed monitoring system.

INTRODUCTION

Booster Injection Kicker System consists of four magnets and each magnet is energised by one pulse power supply. This pulse power supply employees a capacitor bank and a transistor bank. The power supply diagram is showed in Fig. 1 and the operation principle is illustrated as following:

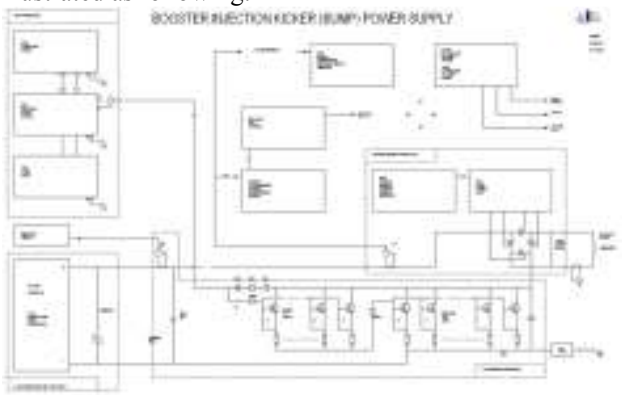

Figure 1: Booster Injection Kicker Power Supply Diagram

The kicker magnet inductance is approximate 10uH. A 0 to 300V DC power supply charges the capacitor bank to an operation voltage, which depends on the injection beam energy. The capacitance of the capacitor is 75nF and the voltage rating is 400V. A transistor bank is connected between the capacitor bank and the magnet load. The transistor bank is used for control the load current. The current waveform is similar to the reference voltage waveform. A current polarity switch bridge can change the load current polarity according different kind injection beam.

The transistor bank which consists of hundreds transistors are driven by a regulator circuit. In order to protect transistor bank over current or over power, a 10 ohm, low power resistor is used to limit the regulator board output power to the transistor bank. During the past years operation, this scheme works all right. However, the 10 ohm resistor fails slowly without any noticeable indication. This resistor slowly failing caused the booster operation many hours down time. So a real time resistor status monitor is required. A new real time resistor status monitor has been made and installed in the booster injection power supply and it can monitor the resistor status from pulse to pulse. After a long time operation, the monitor works well.

REAL TIME RESISTOR MONITOR

The real time resistor monitor is used to measure the 10 ohm resistance from pulse to pulse. Normally the resistance changes slowly. A setting resistor is installed in the circuit. If the measured resistance is higher than the setting resistance, the circuit will send out a status signal to PLC controller and the PLC send a warning signal to machine pet page and warn the machine operator. The circuit is described as following:

Monitor Resistor Bridge Circuit and Comparator Circuit

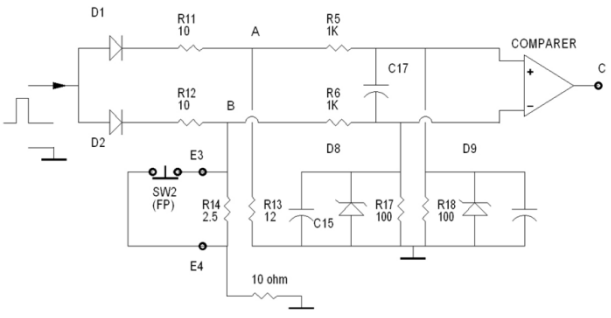

Figure 2: Resistor Bridge Circuit

This is a resistor bridge circuit. The 3 10ohm resistors, a 12 ohm resistor and 2 diodes consist of the resistor bridge circuit, as showed in Fig. 2. When a voltage pulse is add to the resistor bridge, the bridge centre connections, point A and B will send a different voltage to the comparer. If the monitor resistor resistance is lower than 12 ohm, the comparer output always keeps high level. If the resistor resistance increased and the resistance value was higher than 12 ohm, the comparator circuit output will jump to low level and drive the optical

* Work supported by Brookhaven Science Associates, LLC under Contract No. DE-AC02-98CH10886 with the U.S. Dept of Energy
# mi@bnl.gov

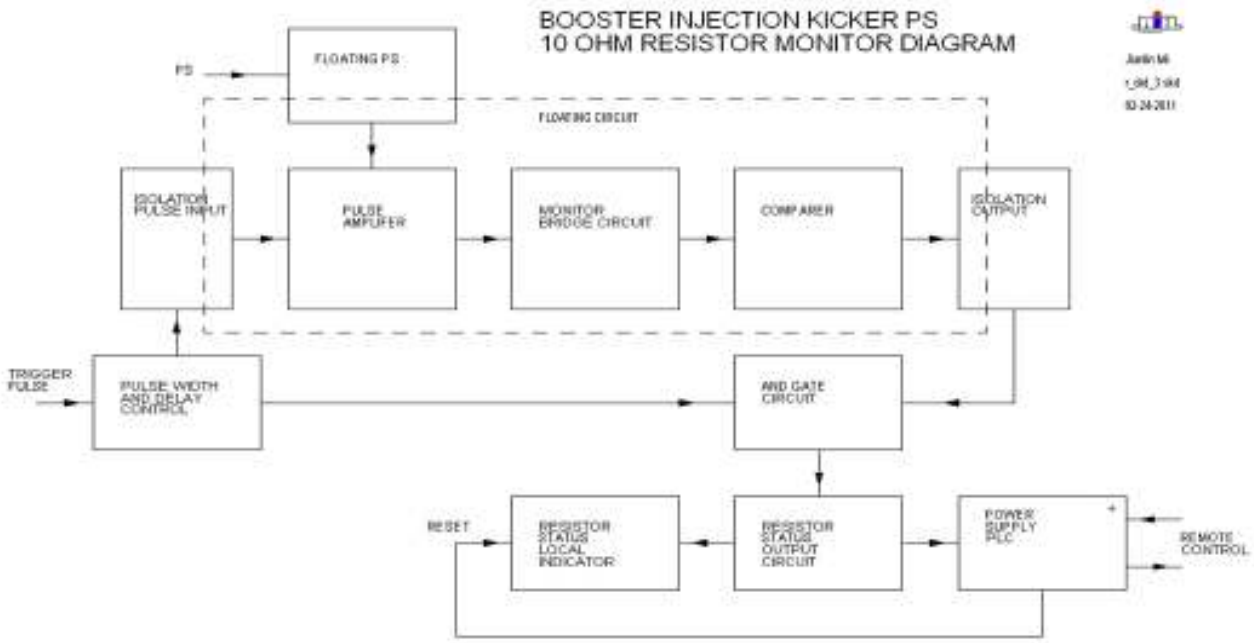

Figure 3: Booster Injection Kicker PS 10ohm Resistor Monitor Block Diagram

coupler to send out a signal.

Pulse Amplifier and Floating PS

The 10 ohm resistor is located in the transistor bank driver input side; the resistor voltage potential is keep changing while the driver is operating. The monitor voltage pulse add to the bridge should be floating on the driver input side, as shown in the figure 3. A DC/DC floating power supply is used as the pulse amplifier voltage source. The DC/DC power supply is made by TDK-LAMBDA. This is a CC-E Series Ultra Compact single DC to DC converter power supply. The isolation voltage is 500VAC. The output power is 1.5W. The input DC voltage is 12V, output voltage is 5VDC. The amplifier input is isolated by an isolation pulse input unit, an optical coupler.

Trigger Delay and Resistor Error Signal Pickup

A 1mS width trigger pulse is added to the resistor bridge through an isolation circuit. As this is a real time detecting circuit, the monitoring function should not operate during the power supply pulsing time. The pulse width and delay control circuit can delay the trigger pulse about 4mS. A resistor error signal pickup use a NAND circuit to pick the resistor error signal monitored. A test pushbutton is installed for checking the monitor. Meanwhile a reset switch is for clear the fault.

Output Circuit

The output circuit includes remote indication and local status indicator. Local indicator shows the resistor status and a button switch to test the monitor circuit. Remote indication will show at pet page through power supply PLC controller unit. And it normally sends an error signal to pet page for warning. Both local and remote control can reset the resistor monitor.

Figure 5 shows a very detail of the monitor schematic.

ASSEMBLY AND INSTALLATION

All parts are installed in a 3U euro card standard format PCB with a board size 100mm×220mm. Because the Booster Injection Kicker Power Supply has operated for more than 20 years, all control chassis are of NIM style. And we are planning to replace the NIM chassis with new euro card standard chassis. So the new PCB will use euro card standard format. The assembled PCB is temporarily in a NIM chassis as shown in Fig. 4.

Figure 4: Assembled PCB

OPERATION

There are 4 pulse power supplies used as the booster injection kicker system. And 4 resistor monitors chassis are installed in each power supply. During the operation the monitor status will show on the machine pet page. It will give the pet control page. A warning reminds if the 10 ohm resistor's resistance is out of the monitor range. And the resistor will be replaced by a new one in time.

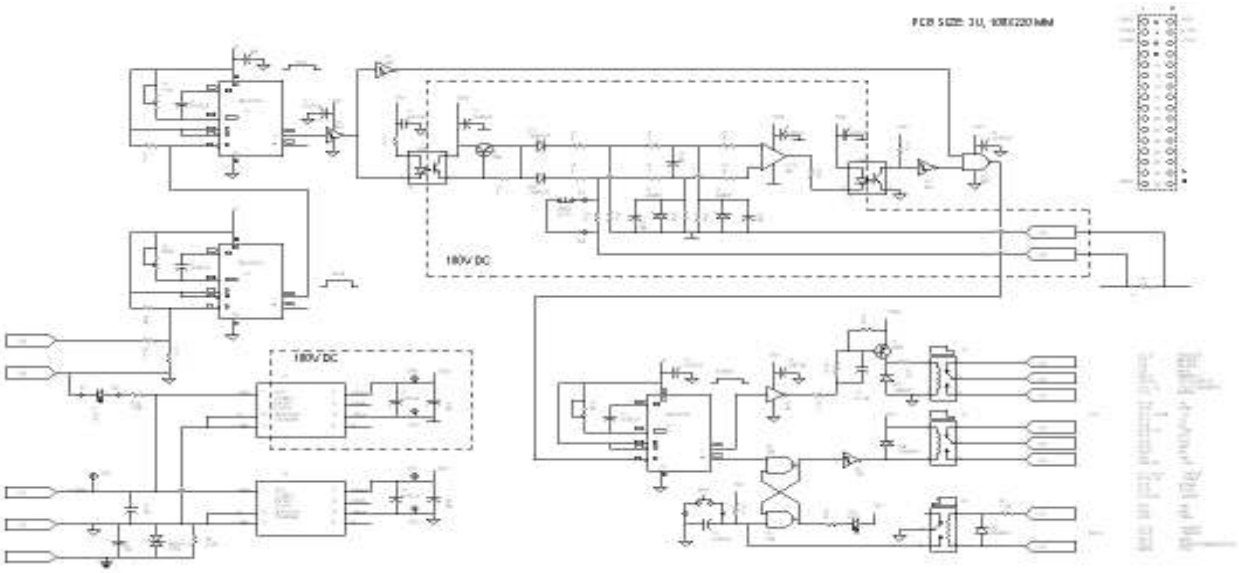

Figure 5: Booster injection kicker 10 ohm resistor monitor PCB schematic

Figure 5: PLC and Control Monitor Chassis

CONCLUSION

This real time resistor monitor circuit shows a useful method to monitor some critical parts in the booster pulse power supply. After two years accelerator operation, it shows that this monitor works well. Previously, we spent a lot of time in booster machine trouble shooting. We will reinstall all 4 PCB into Euro Card Standard Chassis when the power supply system will be updated.

ACKNOWLEDGEMENT

The authors would like to thank the help and support from pulse power group technicians. Especially S. Perlstein and J. Addessi gave us tremendous support during test. They assembled and installed the 4 PCB boards, NIM chassis and tested the system.

REFERENCES

[1] Booster design manual