Study the Module Power Supply's Performance

XIANGDONG SHENG[1], SHAORU ZHANG[2], LIZHI ZHAO[3], JINGHONG XIAO[2], SHAOJIE LI[2], FOR THE LHAASO COLLABORATION
[1]*Institute of High Energy Physics, Chinese Academy of Sciences, Beijing, 100049, P.R. China.*
[2]*College of Physics Science And Information Engineering, Hebei Normal University, Shijiazhuang, 050016, P.R. China.*
shaoruzhang@126.com
DOI: 10.7529/ICRC2011/V04/0642

Abstract: The LHAASO detectors would be operated at Yangbajing, under the condition of high altitude (4300m, 0.6atm) and large dynamic temperature variation (from -25°C to 40°C). To keep the gains of the photomultiplier tubes used stable within 5%, it is required that the temperature coefficient and ripple index of the power supplies should be less than 0.01%/℃ and 0.01%, respectively. Different types of power supplies were tested in an environment simulation system, where the temperature and air pressure are controllable, three of which meet the requirements and are chosen as the candidates.

Keywords: Power supply, photomultiplier tube, temperature coefficient, ripple index.

1 Introduction

The Large High Altitude Air Shower Observatory (LHAASO) project [1] is proposed to study gamma ray astronomy from 40GeV to 1PeV by searching for cosmic ray sources using gamma rays above 30TeV, survey in the whole northern sky for gamma ray sources above 100GeV and gamma ray source observation using high resolution telescopes. Cosmic ray physics from 10TeV to 1EeV in energy spectrum for individual composition above 10TeV and energy spectrum and composition above 100PeV will be studied.

Ground-based Extensive Air Shower (EAS) detector is the only choice to cover the wide (about 8 orders of) energy range. The proposed detector consists of the following components[2]:
• a 1km^2 EAS array (KM2A),
• 4 water Cerenkov detector arrays (WCDAs),
• a 5000m^2 shower core detector array (SCDA),
• a wide field of view (FOV) Cerenkov/fluorescence telescope array (WFCA) and
• 2 large imaging Cerenkov telescopes (LIACTs).

A prototype array of 5% size of LHAASO had been built at the Yangbajing Cosmic Ray Observatory and used to simultaneously measure cosmic rays with the ARGO-YBJ experiment.

The LHAASO detectors would be operated at Yangbajing, under the condition of high altitude (4300m, 0.6atm) and large dynamic temperature variation (from -25°C to 40°C). Even under such a condition, PMTs are required to be operated stably. To keep the gain variations of the photomultiplier tubes within 5%, it is required that the temperature coefficient and ripple index of the power supplies should be less than 0.01%/℃ and 0.01%, respectively. To do that, it's important to choose a suitable voltage source from several kinds of high voltage source.

Based on the requirement of the LHAASO detectors for power supply, two kinds of power supplies can be chosen as the candidates. They are linearity power supply and switch power supply. Linearity power supply can offer stable analogue output. The ripple index is small. However, linearity power supply firstly transforms the input to AC high voltage through a transformer which can increase the bulk and weight of the power supply. Moreover, the transfer efficiency is low (only 30%), and the dissipation power is large. Comparing with linearity power supply, the bulk and weight of the switch power supply is small (less 20% ~ 30% than linearity power supply), because it doesn't need any transformer. Its dissipation power is small, and the transfer efficiency is high (more than 75%). However, the ripple index is large.

Considering energy saving, we chose switch power supply as the candidate power supply for LHAASO detectors, as the LHAASO detectors will be operated for

a long time. Different types of power supplies were tested in an environment simulation system, where the temperature and air pressure are controllable. They are Power supply of CENTRE, LION, and DONGWEN, respectively. Three types of them can meet the requirements and are chosen as the candidates. Power supply of LION has been adopted to supply power for the prototype array of 5% size of LHAASO at the Yangbajing Cosmic Ray Observatory. The successful function confirmed our choice.

2 Test System

In order to choose a suitable voltage source from several kinds of high voltage sources, different types of power supplies were tested in an environment simulation system, where the temperature and air pressure are controllable. Figure 1 is the experimentation box.

Figure 1. The experimentation box

According to the actual working environment of high voltage power supplies, the temperature in experimentation box varies from -40 to 50°C. High voltage power supplies and PMTs are put into the box. At the certain temperature, since it needs several hours for the power supplies and PMTs to reach stabilization, the output voltage and ripple index of power supplies were tested after two hours. Moreover, reading data errors had been eliminated through recording data time after time.

3 Test Results

Based on the requirement of the LHAASO detectors for power supplies, the outputs of power supplies were adjusted to 1500V. Each high power supply needs a low voltage DC source to provide energy, and the voltage of this DC source should be equal to 24V.

For the sake of comparing the performance among the three types of power supplies, all high voltage sources are supplied by the same low voltage DC source, which is made by Shanghai Mingwei.

Figure 2 is the temperature performance of the low voltage DC source. It can be seen from the results that the variation of output voltage is less than 1V when the temperature is changed from -40ºC to 50ºC. That is to say this voltage variation can meet the requirement of high voltage power supply for low voltage source (DC 24V±2V).

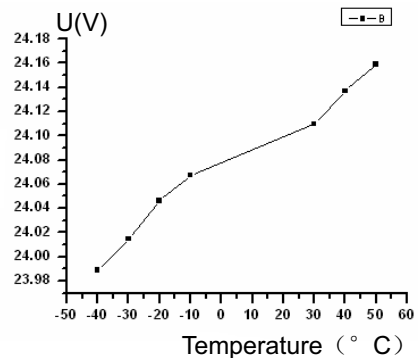

Figure 2. Temperature performance of the low voltage DC source.

3.1 Temperature Coefficient

The CHANGZHOU TONGHUI TH1961 is adopted to test the voltage. This is a high quality digital tabletop multimeter. It will provide precise results in its many application areas. The display has a resolution of 6½ digits (max. count 1.200.000). The DC voltage accuracy is 0.0035%.

The temperature coefficients of three types of power supplies were tested in the experimentation box. Figure 3 is the temperature coefficient.

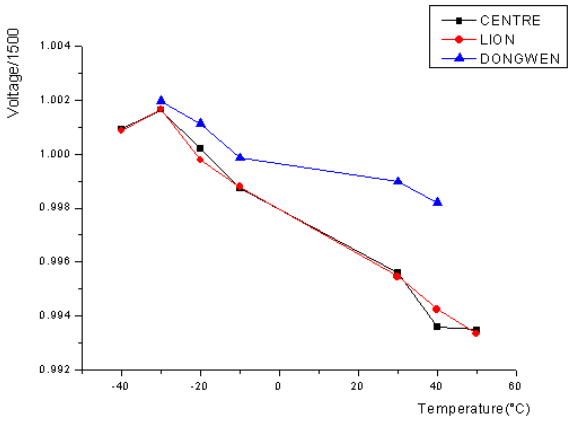

Figure 3. The temperature coefficient.

It can be seen from the results that the temperature coefficient of every type of power supply is about 0.01%/ºC. It can satisfy the requirement.

3.2 Ripple Index

The SUZHOU TONGCHUANG TC2290B is adopted to test the ripple index. This is a 2 Channels AC Millivolt meter. The measured voltage range is from 30uV~100V, the accuracy is +/- 3% of full scale, and the frequency response is 5Hz~2MHz. The input resistor and capacitor are 2MΩ and 20PF, respectively.

The ripple index of three types of power supplies were tested in the experimentation box. Figure 4 is the ripple index.

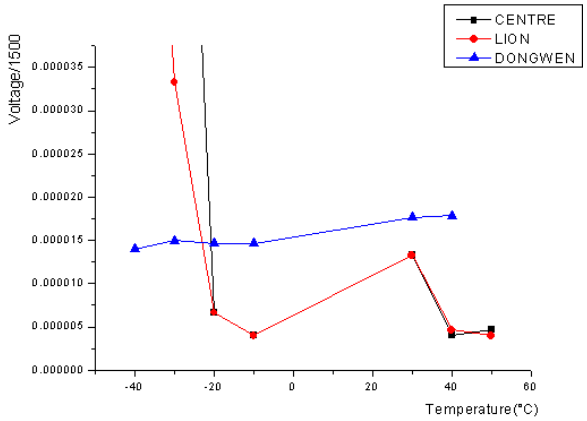

Figure 4. Ripple index.

It can be seen from the results that the ripple index of CENTRE and LION are less than 0.01%, and DONGWEN is less than 0.002%. They can satisfy the requirement.

3.3 Temperature Coefficient and Ripple Index at 0.8atm

The temperature coefficient and the ripple index at 0.8atm are also tested. Figure 5 and Figure 6 are temperature coefficient and the ripple index of DONGWEN, respectively.

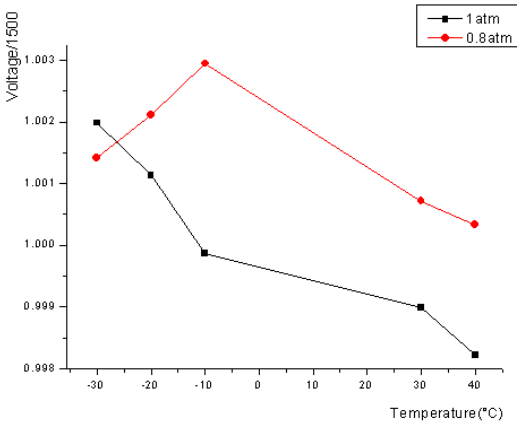

Figure 5. Temperature coefficient of DONGWEN power supply at 0.8atm.

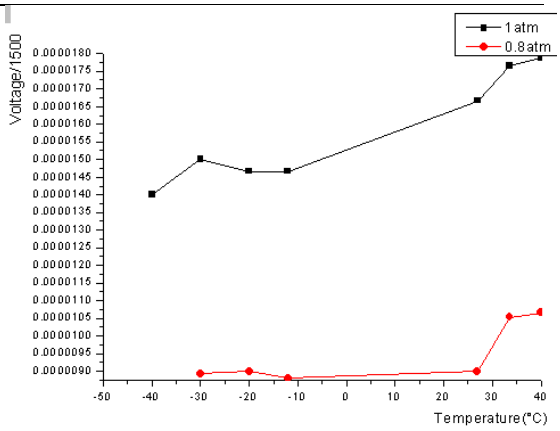

Figure 6. Ripple index of DONGWEN power supply at 0.8atm.

According to these results, we can see that the temperature coefficient is less than 0.008%/ºC, the ripple index is less than 0.001% even if the operation environment is changed.

3.4 Performance with Load Variation

Generally, a voltage divider is used for a PMT operation to apply interstage voltage to the dynodes of a PMT [3]. A voltage divider usually consists of a series of connected resistors and some capacitors, it is called resistor base. Figure 7 shows its schematic drawing. In this figure, symbols of K, Dyn and P mean cathode, dynode and anode, respectively. Resistors divide a total applied voltage and supply constant voltages to the dynodes. Capacitors supply electric charge to each output pulse to keep constant interstage voltages in short term.

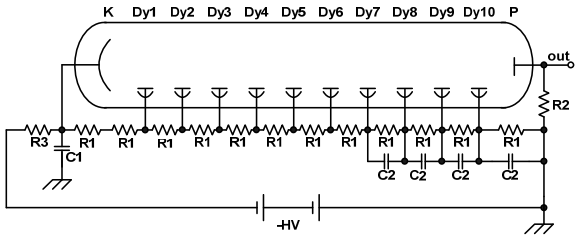

Figure 7. Schematic drawing of a voltage divider.

The performance with load variation of every power supply at 40ºC is also tested. Table 1 is the performance with load variation under different operation conditions. During the course of testing, DC voltage source, high voltage power supply, and PMT are all put into the experimentation box, because they will operate together when the LHAASO project is running.

From Table 1, we can conclude that the output voltage will fluctuate when the load varies. But the range of voltage fluctuation is less than 0.048%, which can be accepted.

voltage	LION(1atm)	DWEN(1atm)	DWEN(0.8atm)
open circuit	1498.68966	1499.01759	1498.55852
only with PMT	1498.1272	1498.29618	1498.33177
with PMT and photons	1498.7648	1498.50362	1498.14458

Table 1. The performance with load variation.

4 Conclusion

The LHAASO project is being built at Yangbajing so that the evolution of galaxies and the acceleration mechanisms in gamma ray sources can be thoroughly understood. It is well known that the altitude is very high and the temperature variation is large at Yangbajing. It is essential to find out a type of appropriate power supply for the LHAASO detectors. So the detectors can be operated stably. Different types of power supplies were tested in an environment simulation system, where the temperature and air pressure are controllable. The experimental results show that three types of them meet the requirements and are chosen as the candidates. These results are advantageous to the in-depth development of the LHAASO project and the test of the high energy physics.

Acknowledgments

This work is partly supported by the Knowledge Innovation Fund (H85451D0U2) of IHEP, Beijing.

References

[1] Cao, Z. et al., for the LHAASO Collaboration, Proceedings of 31th ICRC (2009).
[2] He, H. et al., for the LHAASO Collaboration, Proceedings of 31th ICRC (2009).
[3] Hamamatsu Catalog, “Photomultiplier Tubes” (Cat. No. TPMO 0002E).