# VSWR Protection System and Cavity Frequency Tuning System for RF Power Source at CSNS LINAC



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#### Abstract

When electrical breakdown in the form of arcing in the accelerator cavity, high-power RF signal reflect to the RF power source, which brings severe damage to the RF power source and wave-guide output window. In this paper, we introduce a Voltage Standing Wave Ratio(VSWR) Protection System to avoid this damage. Once the system detect VSWR higher than the threshold value, the system spread out a signal quickly to cut off excitation source of RF power source within 1 us. In this System, VSWR value and protection number can be displayed in screen, protection time in each pluses can be set manually. This system is now used in CSNS LINAC RFQ, Buncher, Debuncher, DTL power source systems. By the way, The tuner control system which tuning the cavity's resonate frequency is shown at the end of the paper.

#### INTRODUCTION

China spallation neutron source(CSNS) is located in Dongguan city in Guangdong province. The infrastructure and equipment manufacture are now in progress. The RF system for the 81 MeV Linac requires 9 units of RF power sources: two 4616 tubes for RFQ, 4 klystrons for DTLs, and 3 solid state amplifiers for two bunchers and one debuncher. A VSWR protection system is introduced to avoid high power reflect from cavity to power source.

The digital board consists of a motherboard and one daughterboards, the daughterboards owns eight 14bit, 72MHz ADCs. The core devices in the motherboard are one Altera straix II FPGA and two TI C6000 DSPs, the primary control logic is implemented in the high-speed and high-density FPGA, the DSPs is mainly responsible for the communication with IPC through Ethernet and some coefficient calculations. This structure can reduce the logic elements usage and simplify the floating point arithmetic, also make the Ethernet communication easy to realize.



Fig. 1. Scheme of CSNS LINAC RF System

CRF System great damage to equitments chosen to provide enough power to drive ADC, which

## SCHEME OF THE VSWR PROTECTION SYSTEM

Take DTL cavity for example, the RF power system contains of CPI 3MW klystrons, ferrite circulator, circulator dummy load. Derect couplers are install in 4 points: klystrons output, circulator output and circulator dummy load and cavity input. The circulator output and the cavity input are in one wave-guide but have a distance of about 12 meters. Every coupler has both forward port and reflect port. Eight logarithmic detectors detect every channel and output DC voltage proportional to the RF power, eight ADC chips sample the voltage with a clock of 72MHz and send the data to FPGA, DSP coroperate with FPGA is used to transfer data to IPC through network . FPGA calculate the power and VSWR , once large reflect power detected, FPGA spread a signal to cut off power source. The VSWR vulae, protection numbers, power data and power waveform are sent to the IPC in real time. All the analog units including the analog moudle (AM) and clock distribution module (CDM) are put into a temperature stabilizing chamber. A high precision power supply is used for the digital board .



is 50 Ohm inputs

The active detector is



Fig.5. Linear of Detector



Fig.6. Power Detectors

#### PERFORMANCE

CSNS LINAC RF system work at 650us 324MHz pulse-mode with 25Hz repetition rate. The VSWR protection system have two mode of RF blocking. Once the system detect VSWR over the threshold, it cutoff RF power in the first pulse but recover in next pulse, this call PULSE BLOCKING. If pulse blocking take place continuously in every pulses and the protection number in one second exceed the setting number, the system will cutoff the RF signal forever until manual reset, this call FOREVER BLOCKING. The number of arcing times in one second can be adjusted according to the cavity's vacuum conditions. The response time of the system is less than 1us, which is satified the requirement. The power waveform and protection number translate to IPC in real-time.





	Ely Input	Cir Output	Cir Load	Cav Input
Forward	1553.5Kw	1515.3Kw	11. 3Kw	1487.2Kw
Reflect	6.4Kw	11.5Kw	0.4Kw	40. SKw
VSWR	1.14	1. 19	1.44	1.40

### Fig.8 Real-time power meter



Fig.10. Protection Numbers

SCHEME OF THE CAVITY FRECENCY TUNING SYSTEM



Fig. 3. waveguide directional coupler



Fig.4. Ferrite circulator

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## CONCLUSION

It's a very important part for high power source ,because the cavity is always arcing during aging,and also acing sometimes after aging. Power source can't work well without this protection system. To author's knowledge ,this is first digital VSWR protection used in accelerator, and it is useful ,convenient and intelligence.