DEVELOPMENT OF A CW SOLID STATE AMPLIFIER FOR THE LONGITUDINAL FEEDBACK SYSTEM OF BEPCII*

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Abstract

A Solid State Amplifier (SSA) has been developed for testing beam feedback system of the BEPCII of the Institute of High Energy Physics (IHEP), CAS. The output power of the SSA is 100 W with a CW frequency range from 1000 MHz to 1250 MHz. After three generations development, the SSA has become a professional power source. The paper has introduced the development of the SSA and the skills used in the SSA.

INTRODUCTION

A main issue for the charged-particle accelerators is the beam longitudinal and transverse instabilities, which are normally induced by the higher-order-mode (HOM) [1-4]. In order to reduce the HOM effects, the longitudinal and transverse feedback systems have been used in the storage rings. Such a system normally includes the front-end electronics, signal processing electronics, back-end electronics, amplifiers and a kicker. The feedback system receives and analyses the signals from BPM (Beam Position Monitor) system, and gives the feedback signals to drive the kicker. The feedback signals' power is not enough to drive the kicker directly. An amplifier is used to amplify the feedback signals to drive the kicker. The electromagnetic fields been setup in the kicker reduce the beam instabilities.

In order to damp the transverse and longitudinal coupled bunch instabilities caused by HOMs of RF cavities and resistive wall impedance in the BEPCII storage rings, the longitudinal feedback system and transverse feedback system are used [5]. Figure 1 shows a digital longitudinal feedback system (LFB) for both rings of BEPCII. Here ADS-SSA-1250-100 is a solid state amplifier (SSA) being used in the system, as shown in Fig.1.

For matching a flexible working frequency of the kicker, a big frequency range of the solid state amplifier, and a power margin of 25% have been required. To get a good quality SSA, we have developed the SSA through three generations. Finally, a good quality SSA has been developed.

The frequency, power and other parameters of the first generation SSA could meet the specifications, but it has a good quality in its self-safety protection system.

After improving the properties of the first generation SSA, the second generation has the good self-safety protection system and man-machine interface. But the remote control function was not enough to meet the high requirements.

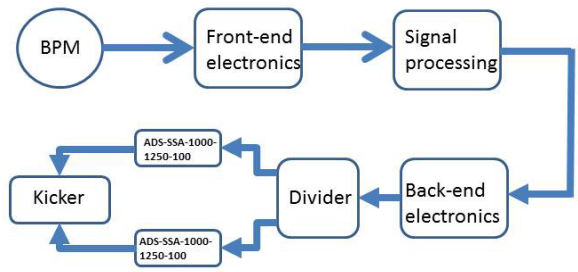

Figure 1: An overview of LFB system of BEPCII.

After upgraded the control system, the third generation SSA has the good remote function, and its stability has been improved sharply.

DESIGN OF THE SSA

The parameters of the SSA working in the longitudinal feedback system (LFB) for both rings of BEPCII are:

（1） Frequency range: 1000~1250 MHz
（2） Output power: >115W (50.6dBm)
（3） Gain: ≥ 50 dB
（4） Gain flatness: ± 1.0 dB
（5） Maximum input power: 5dBm
（6） Temperature compensation: 0.06dB/℃
（7） Input/output SWR: < 1.5
（8） Third-order inter intermodulation: 10dB ≥ P1dB
（9） Harmonic suppression: ≥20 dBc
（10） Noise suppression: ≥ 70 dBc
（11） Input and output port type：N-50K-female
（12） Working temperature range: -10~+50℃
（13） Input and reflection power protection
（14） Self-safety protection

RF Module Design

Based on the available RF amplifier's chips and parts, the amplifier's power amply system includes a 6W pre-amplifier module and a 100W amplifier module. Their parameters should meet all the specifications of the whole system, even better more. Figure 2 shows the RF modules developed by ANDESUN Inc.

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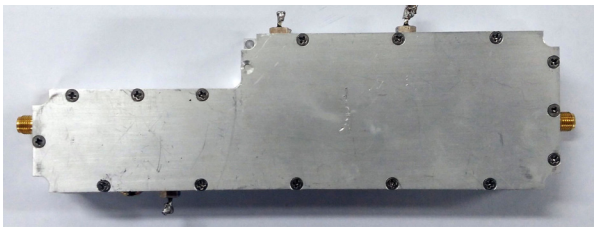
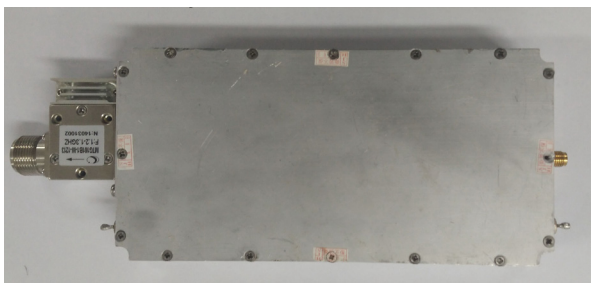


A. 6 W RF module.



B. 100W RF module.

Figure 2: RF modules.

Signal Detectors

Two direction couplers are used to detect the input, output and reflection power. One's coupling factor is 5 dB, another's is 40 dB. The RF signals from the direction couplers are detected by three detectors, which are connected to a power-detector system, as shown in Fig. 3. The power source's signals are displayed by the light emitting diodes.

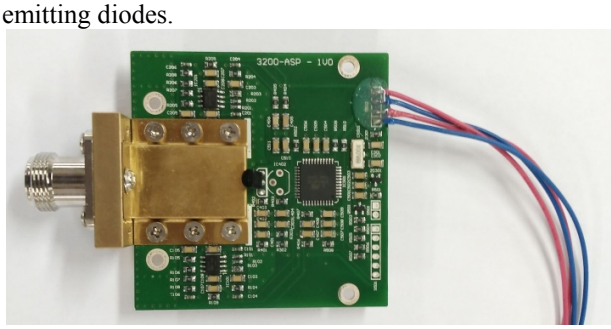


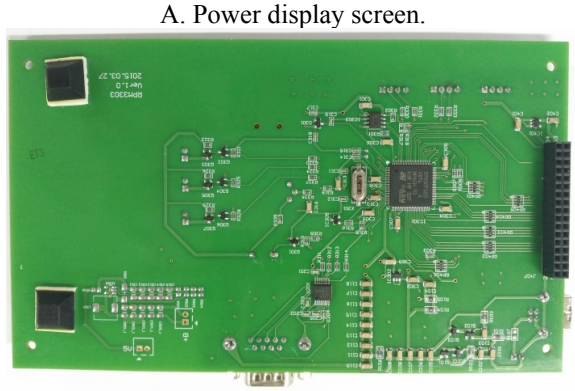
Figure 3: A power detector.

Control System

A power-detector system, which was developed by ANDESUN Inc., has been used to measure the input power from the 5dB-direction-coupler, and the reflection power and output power from the 40dB-direction-coupler. The board is driving a digital power displayer. If the input power is higher than 5dBm, a +5V signal will be outputted, and will drive a RF switch and a reset switch of the input power. If the reflection power is higher 100 W, a +5V signal will be outputted, will drive a RF switch and a reset switch of the reflection power. The hardware of the power-detector system includes a display screen of 7 inches, three power detectors, one processing boards, as shown in Fig. 4.

A control board, which has been developed by ANDESUN Inc., can process the signals from the power-detector system, the power source's signals, and drive the RF switch. This control board has the good function to communicate with the power-detector system and remote control system, as shown in Fig. 5. The system temperature monitor is also connected.

A. Power display screen.



B. Process board.

Figure 4: Power-detector system developed by ANDESUN Inc.

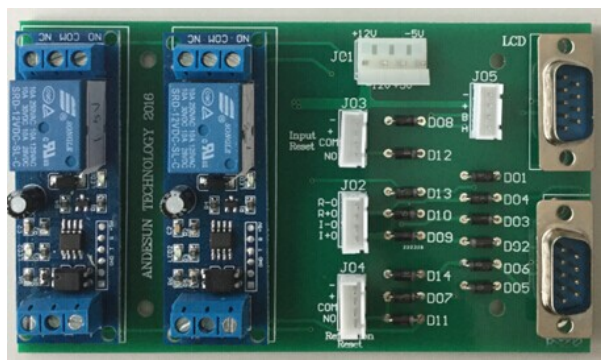


Figure 5: Control integrated-circuit-board developed by ANDESUN Inc.

Power Sources

The power sources includes a AC/DC module of 5 V and 40V and a AC/DC module of 12 V. They are used to drive the RF amplifier modules, RF switch, display screen, control board, power detector's board, etc..

SYSTEM INTEGRATION

The whole system includes the power protection equipment, emergent switch, cooling system, cables, box and other parts, except the RF modules, signal detector system and control system. Because the total RF output power is about 100W, normally about 75W, we used an air cooling system. It is composed of the heat-exchange boards and fan, etc.. The final assembled SSA is shown

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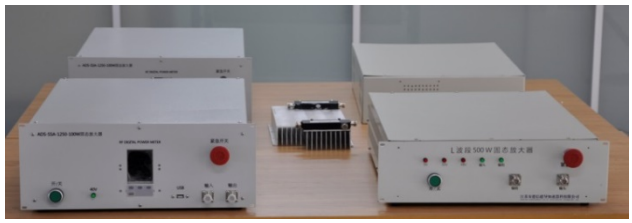
in Fig. 6. Figure 6 also shows the different generation SSAs.

Based on this technology, we have developed high-quality CW solid state amplifier with an output power of 1000W, working frequency of 1.3GHz for Shanghai Institute of Applied Physics (SINAP).



A. First (right) and second (left) generation SSA.

B. Third generation SSA for BEPCII.

C. Third generation SSA of 1.3 GHz, CW and 1000W for SINAP.

Figure 6: Different generation SSAs.

TESTING RESULTS

SSA Testing Result

The testing results of the SSA displayed that all the parameters have met the specifications. After 3-day full power testing, the machine has shown that can work stably without any trips.

SSA Testing in the LFB System of BEPCII

After installed the SSA in the LFB system of the BEPCII, we have taken all the testing procedure. The testing results have shown that the SSA can service the system well.

Now the LFB systems performed well. When LFB system turns on, the longitudinal sidebands were eliminated and the bunch luminosity became almost same along the bunch trains, as shown in Fig.7 and Fig.8

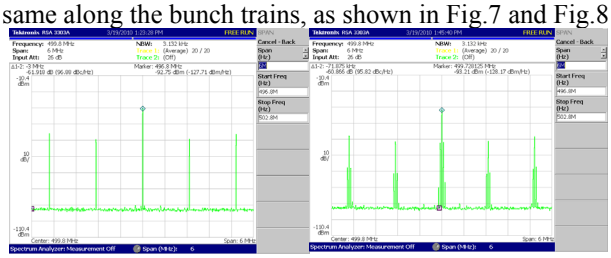


Figure 7: Sidebands on the spectrum when LFB turns on or off.

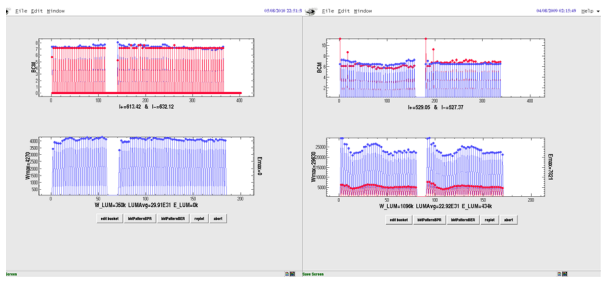


Figure 8: Bunch luminosity when LFB turns on or off.

CONCLUSIONS

Nanjing University and ANDESUN Inc. have developed the SSA for the LFB system of BEPCII successfully. The operation results show that the SSA can service for the LFB system of BEPCII well.

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