1kW *S*-Band RF Solid State Amplifier for BEPC Linac Microwave Driver System

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Abstract This paper presents the development of a 1kW *S*-Band RF Solid State Amplifier (SSA) for the BEPC Linac. 1kW peak power with a pulse width of 2—10μs under low voltage operation is achieved by combining eight 160W high power Solid State Amplifiers using a low-loss(0.3dB) combiner. Other key performance parameters are: RF phase drift during pulse $\leqslant \pm 1$ degree, RF rise time/fall time is 88ns/40ns, RF pulse flatness is 0.7%, and RF power stability is 0.1dB.

Key words solid state amplifier, module, peak power

1 Introduction

In the BEPC Linac, a microwave driving signal of 1kW peak power, 4μs pulse width supplies the first klystron. Parts of output power of the first klystron drive other 15 klystron amplifiers. The old RF driver system which uses TWT amplifiers has some defects, such as: unsteadiness, high failure rate, short life time and not very well performance. To overcome these shortages, we develop a new RF driver——1kW *S*-Band RF Solid State Amplifier instead of the old type.

Compared with TWT amplifier, SSA has many obvious advantages which make it an ideal equipment for the BEPC Linac Microwave Driver System. First, SSA has good performance and high reliability. Performance parameters were critically measured and mentioned above in the abstract section. Second, SSA has low voltage operation for safety and high efficiency, and its long life time is estimated. Final, SSA has many features for maintainability and availability as follows: front panel input/output RF power display & adjustment, front panel pulse width control, fault monitoring display panel, power supply excess current & voltage protection function.

2 Design

A block diagram of the 1kW *S*-band RF SSA is shown in Fig. 1. The overall gain is more than 50dB which is achieved by three stages of amplification. The outputs of the first and second stage amplifier are 3W and 20W, respectively. The output stage consists of two 580W amplifiers module which are combined.

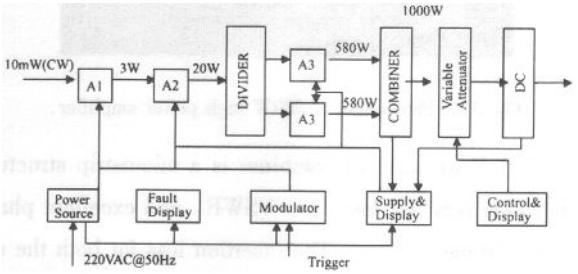

Fig. 1. Block diagram 1kW solid state amplifier.

The heart of the SSA is the 580W amplifier module. Its block diagram is shown in Fig. 2. The architecture for the 580W amplifier consists of three stages of amplification that amplify a 4W input signal to a 580W output signal. The first stage is a 30W power transistor. The second stage transistor is a 160W device followed by a third stage

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of four paralleled 160W transistors, shown in Fig.2. A four way power divider/combiner consisting of 2 levels of two branchline micro-strip couplers is used to excite and collect power from the four parallel output stage transis-

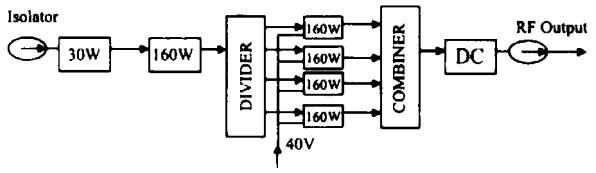

Fig.2. Block diagram of 580W high power amplifier.

A photograph of the 580W amplifier module is shown in Fig.3. It consists of a low cost network that is fabricated in a hihg dielectric constant, low loss microstrip package. It contains input and output isolators that along with the divider/combiner allow for "hot replacement" of amplifier.

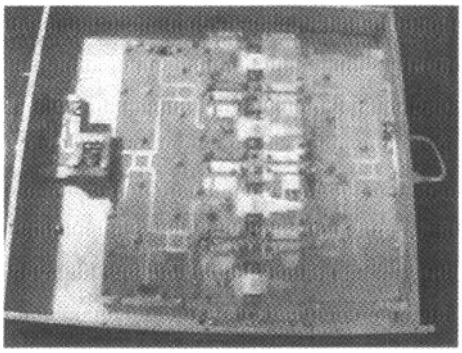

Fig.3. Photograph of 580W high power amplifier.

2:1 Power divider/combiner is a microstrip structure that yields very low loss, low VSWR, and excellent phase and amplitude balance. The insertion loss for both the divider and combiner was measured at <0.3dB, the amplitude and phase variation were ± 0.1dB and $\pm 3°$ respectively. VSWR was <1.3.

3 Experimental results

A photograph of outline of the 1kW SSA is shown in Fig.4. Performance parameters were critical measured. The ideal measuring result is obtained and detail presented in table1. The pulse waveform of the 1kW SSA output power is shown in Fig.5.

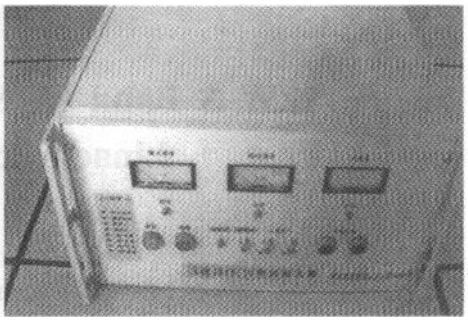

Fig.4. Photograph of the SSA view.

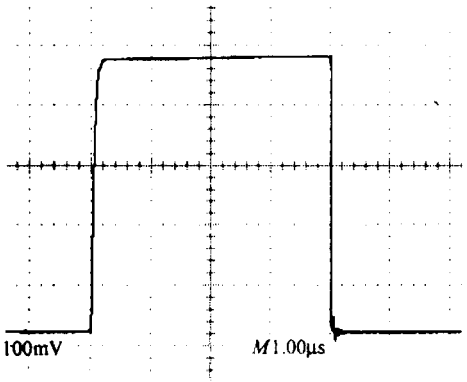

Fig.5. Output waveform of the 1kW SSA pulse power.

Table 1. Designed and measured parameters of 1kW solid state amplifier

Parameters	Unit	Designed	Measured
Frequency	MHz	2856	2856
Bandwidth	MHz	±2.5	2853—2868
PulseWidth	μs	2.0to10	2.0to10
PPS		1to100	1to100
Trigger	1μs	±5V	±5V
Power In	W	0.5	0.006—0.01
Power Out	W	1000	1030
RF Gain	dB	≥34	≥50
Phase Drift	Deg max.	< ±1	±1
Rise/Fall Time	μs	<0.1/0.1	0.088/0.04
RF Pulse Flatness	max.	0.5%	0.69%
RF Power Stability	dB	±0.2	±0.1dB

4 Conclusions

The development and performance of 1kW *S*-Band Solid-State Amplifier has been presented. This equipment achieves high reliability and good performance which are

required by BEPC Linac microwave driver system. This equipment has been served the BEPC Linac from April of 2001. Its operating status is good with no problem occurred.

References

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S 波段 1kW 固态放大器

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摘要　S 波段 1kW 固态放大器用于北京正负电子对撞机直线加速器大功率速调管的微波激励. 阐述了其工作原理和性能指标,并对其核心部分——580W 放大器模块作了重点介绍. 该放大器达到的主要技术指标如下:工作频率为 2856MHz,输出最高脉冲功率为 1030W(在放大器合成后输出端测量),脉冲宽度为 2—10μs,脉冲前沿/脉冲后沿分别是 88ns/40ns,脉内平顶为 0.7%. 该放大器自 2001 年 5 月在加速器上运行到现在,运行状态良好.

关键词　固态放大器　模块　脉冲功率

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